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A COMPUTER MODEL FOR EVALUATING COMMUNITY PHOSPHORUS REMOVAL STRATEGIES

Donald S. Yeaple, et al

JBF Scientific Corporation

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A COMPUTER MODEL FOR EVALUATING COMMUNITY PHOSPHORUS REMOVAL STRATEGIES

By

Donald S. Yeaple
David A. Barnes
Francis A. DiGiano

JBF Scientific Corporation
2 Ray Avenue
Burlington, Massachusetts 01803

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EPA REVIEW NOTICE

This report has been reviewed by the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

The Environmental Protection Agency has not verified this computer model by using it to calculate the phosphorus removal costs of many existing sewage treatment plants, and comparing these calculated costs with the known costs of these operating plants. The Office of Air and Water Programs would appreciate receiving results of any such comparisons. Users of the model may borrow a copy of Sensitivity Analysis of a Phosphorus Removal Strategy Computer Model from the Office of Air and Water Programs. This unpublished report analyzes the sensitivity of the model's parameters.

The Soap and Detergent Association has made the following comment on this model.

"The phosphorus substitutes available at this time have costs associated with their use which may partially offset or totally outweight the savings in phosphorus removal costs which would ensue from a ban on phosphorus in detergents. Examples are higher raw material costs, shorter garment life, increased frequency of washing machine service calls, loss of flame retardancy of finishes on children's sleepwear, increased ingestion hazard, potentially increased cost for treating the phosphate replacement at the waste treatment plant. The costs do not lend themselves to inclusion in a computer program. Every user of this program is advised to evaluate magnitude of these off-setting costs in the community of concern before drawing any conclusions."

ABSTRACT

A computer model for evaluating a number of strategies for removing phosphorus in wastewater has been developed. The influence on total treatment cost of several non-treatment strategies such as the elimination of phosphates in detergents can be evaluated in terms of the treatment cost at local waste treatment plants.

A review of phosphorus removal technology was conducted in order to determine what methods should be included as available techniques in a treatment strategy. Chemical precipitation techniques were selected as being both available and most effective at the present time and in the immediate future. (M)

The model reports to the user the total cost of a selected strategy for removing phosphorus. Over 21 treatment schemes with several sludge handling schemes can be selected and evaluated depending on local conditions. The computer guides the user through a series of questions and answers to develop a local profile and prediction of future conditions.

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SECTION I

CONCLUSIONS

1. This model is for evaluating strategies available to communities for the control of phosphorus in municipal wastewater. The model will report to the user the cost of various strategies which include the alternatives of controlling phosphorus concentration in the raw sewage, limiting industrial discharge of phosphorus and treating by various methods at the wastewater treatment plant. The costs are computed from amortized capital costs, operation and maintenance expenses, and materials cost for a predetermined time period.

2. The costs of phosphorus removal strategies will vary depending on type of local treatment, the quantity of phosphorus in the treatment plant influent and the final effluent concentration requirement. For a hypothetical community of 50,000 population served by a 5 MGD trickling filter plant, it has been found that alum treatment after the trickling filter to achieve an effluent of 2.0 mg/l total phosphorus results in a cost of 7.7 cents/1000 gallons. The corresponding cost to achieve an effluent of 0.5 mg/l is 13.7 cents/1000 gallons and involves the addition of multi-media filtration to the treatment scheme. These cost estimates are for a stable population. The model will also predict costs based on various growth rates. In contrast to the above, a hypothetical 200,000 population city served by a 20 MGD activated sludge plant can achieve 2.0 mg/l phosphorus effluents at a cost of 6.2 cents/1000 gallons using a scheme of ferric chloride added to the aeration basins. If an effluent limit of 0.5 mg/l phosphorus is required, a tertiary single-stage lime treatment scheme is the least-cost scheme at a cost to the community of 9.4 cents/1000 gallons.

Cost to the community may be substantially reduced if State and/or Federal grant funds are available to assist with financing. Costs may also be reduced by controlling the phosphorus load to the treatment plant through imposition of legislative limits on sale and use of detergent products containing a high percentage of phosphorus. Restriction of significant phosphorus discharges to the sewerage system from industrial and commercial sources may also be enforced to reduce treatment costs to the community.

The model provides for cost computations using these alternatives on financing and control of phosphorus discharged to the sewerage system. The model requires as an input a description of present treatment facilities and a prediction of the community growth rate. The most cost-effective treatment scheme can then be determined.

3. In addition to being a valuable tool for planning local strategies, the model can be used to evaluate and optimize various treatment processes. Changes in design parameters, costs of chemicals, transportation rates, power costs, and the introduction of automation to reduce manpower requirements can all be evaluated as to their effect on overall treatment costs.

4. Several inconsistencies have been noted in the generally accepted assumption that approximately 50 percent of the phosphorus in domestic wastewater is due to the use of phosphate detergent products. In several reports this assumption appears to be justified on the basis of an annual per capita use of 27 pounds of detergent. This assumption may be erroneous for use in the model by all communities. If legislative controls will be imposed on percent phosphorus in detergents and industrial or commercial sources of phosphorus controlled it is important that the community or user of the model know the specific ratio of detergent phosphorus in the sewage and the industrial-commercial contribution in order to arrive at a valid best strategy for phosphorus removal.

5. After reviewing the current technology for phosphorus removal, chemical precipitation was selected as being the most widely accepted and effective means of removing phosphorus from wastewater.

6. Four levels of effluent phosphorus concentration (total unfiltered phosphorus) were assumed to be achievable depending upon the type of treatment provided. These are:

2.0 mg/l	(Option 1)* Chemical addition to the primary clarifier

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*See p. 34-35 and Table 14, p. 150, for description of process options.

	(Option 2) Chemical addition to a flocculation basin prior to the primary clarifier
	(Option 3) Chemical addition to the aeration basin
	(Option 4) Chemical addition after the trickling filter.
0.5 mg/l	(Option 5) Chemical addition to the aeration basin plus multi-media filtration or Chemical addition after the trickling filter plus multi-media filtration
	(Option 6) Addition of lime to a flocculation basin following conventional secondary treatment
0.3 mg/l	(Option 7) Addition of alum or ferric chloride to a flocculation basin following conventional secondary treatment--one stage.
0.1 mg/l	(Option 6) Addition of lime to a flocculation basin following conventional secondary treatment--two stages

7. Chemical precipitation provided seven alternative process schemes: (1) addition to the primary clarifier; (2) addition to a flocculation basin prior to a primary clarifier; (3) addition to the aeration basin; (4) addition to the secondary clarifier of a trickling filter; (5) scheme (3) or (4) plus a multi-media filter; (6) addition of lime to a tertiary treatment process; and (7) addition of alum or ferric chloride in a tertiary process.

8. With chemical precipitation, sludge production is increased. Although stoichiometric equations can be used to predict the total additional sludge, variations to those estimates have been noted

in many sources. In the future, there may be a trend toward using oxygen in activated sludge and aerobic digestion schemes. This will lead to decreased sludge production and improved sludge dewatering and will probably have a beneficial effect on the costs of sludge handling particularly for larger treatment plants.

9. Estimates of design parameters for gravity thickening, vacuum filtration, sludge drying beds, anaerobic digestion, flotation thickening and multiple-hearth incineration have been presented.

A number of effects on the sludge handling capacity of a treatment plant are a direct result of chemical addition. The following have been noted:

a. Vacuum filter yields have been noted to decrease with alum sludges and increase with lime and ferric chloride sludges.

b. Lime sludges have an adverse effect on anaerobic digestion unless carefully controlled. Iron and aluminum sludge will not noticeably affect anaerobic digestion.

c. Some release of phosphorus from the sludge may occur in anaerobic digestion of iron sludges.

10. In regard to chemical addition schemes the following conclusions apply:

a. Chemical addition to the primary clarifier may enhance the removal of BOD and suspended solids in addition to phosphorus removal. However, because the hydrolysis of complex organic and inorganic phosphorus compounds is incomplete prior to biological treatment, the expected final effluent phosphorus concentration is quite variable and significantly higher than that achievable by tertiary phosphorus removal. Filtration of the primary effluent must be practiced if low values are to be achieved.

b. Lime dosing cannot be based upon influent phosphorus concentration. The dosage of lime is related to the alkalinity of the influent. Higher alkalinities require higher dosing. As a practical limit, wastewaters having alkalinity less than 150 mg/l as $CaCO_3$ are not amenable to lime treatment because pH will increase to levels greater than 10. 0 before effective phosphorus removal occurs. This will be unacceptable if biological treatment follows. For alkalinities between 150 and 300 an addition of 150 mg/l of CaCO is required while 200 mg/l of CaO is required for alkalinities greater than 300. Estimates of dosage are also a function of application point--primary versus tertiary.

c. Lime addition in tertiary treatment offers two alternatives--single and two stage. The choice of process depends on alkalinity. Single stage can be used when alkalinity is greater than 200 mg/l, while two stage is required for low alkalinity wastewater.

d. Alum addition in tertiary treatment is also feasible. While lime addition requires that recarbonation be practiced, alum does not because pH is depressed to a manageable extent rather than increased. Alternatively, lime can be recovered from tertiary sludge while alum, thus far, cannot.

e. Data thus far reported indicate that the dosage of iron or aluminum is dependent upon influent phosphorus concentration but the exact ratio of cation/phosphorus is not well established. In the computer model an Al/P ratio of 2/1 and an Fe/P ratio of 3. 1/1 were assumed when the chemicals were added to the primary clarifier and 1. 5/1 and 4/1 respectively when added to the aeration basin.

SECTION II

PURPOSE OF MODEL

The computer model developed in this program can be used by local communities or their consulting engineers to plan the expansion of present wastewater treatment facilities or provide for new ones in order to meet requirements for phosphorus removal.

The model as it is presently conceived is based on best available data. In order to insure its usefulness, EPA plans to periodically update the model as additional performance data on phosphorus removal processes becomes available.

Some communities presently using extended aeration systems for waste treatment will not find the model particularly useful. There is no existing data for modeling purposes on the performance of extended aeration with chemical addition for phosphorus removal. In view of the additional sludge production it would not appear that these systems will be readily modified at this time.

We believe that substantial reductions in the production of sludge may be realized with pure oxygen thus reducing costs of sludge handling modifications. The model will be updated if and when sufficient data are available to substantiate significant removal of phosphorus by this process.

SECTION III

INTRODUCTION

Scope and Purpose

Accelerated eutrophication in lakes and slow moving rivers is a contemporary problem involving increased biologic productivity as a result of increased nutrient enrichment. Both point and non-point sources of nutrient addition have been identified. Suggested corrective measures have included the reduction of nutrient inflows by such actions as diversion of wastewater effluents to bodies of water with more assimilative capacity, additional wastewater treatment to remove nutrients from industrial and municipal effluents, product modifications such as reducing phosphorus content of detergents, control of land use practices to reduce nutrient drainage from fertilizers, and treatment of agricultural drainage. The first three measures listed above deal with the control of point sources while the last two are concerned with non-point sources.

A basic strategy of controlling eutrophication is presently linked closely to the reduction or elimination of phosphorus, a nutrient which does not have a gaseous phase as does nitrogen, and thus does not replenish phosphorus in water through the atmospheric gases. For this reason, the reduction of phosphorus input to a body of water is the basic strategy chosen for the control of eutrophication. There is some indication that the atmosphere may contain phosphorus contributed by dust particles or through air pollution and this may be a significant contribution of nutrients in some areas. The specific methods for achieving phosphorus removal cannot be adequately specified until the local conditions have been thoroughly determined and analyzed.

In the program discussed in this report we have dealt primarily with point sources and in particular the control of point sources at a municipal waste treatment plant. The first phase of the program included a review of various alternatives for updating existing treatment plants for phosphorus removal. We were concerned with the feasibility of adding equipment to existing plants and with isolating the additional capital and operating costs so that the specific costs for phosphorus removal could be identified. We also were concerned with the possibility that techniques not presently suitable for routine introduction might become feasible within the next 5 to 10 years. Thus, the first phase was a review of both existing and possible future techniques for phosphorus removal.

The second phase of the program involved the formulation of a computer model for evaluating the various strategies for reducing phosphorus in the effluent of municipal treatment plants. Since at the present time there is no national limitation on the use of phosphorus in detergents, the individual states and municipalities have been faced with the problem of legislating their own controls. In many cases this has been done and has affected the decision to remove phosphorus by additional waste treatment. Each of the possible strategies has an associated cost, thus the objective of the model is to determine the best strategy on the basis of cost for controlling effluent phosphorus within some given limit.

The model has been designed specifically for planning purposes and can be used by municipalities, planning agencies and government policy organizations. Input information is determined on the basis of a series of questions and answers designed to define the specific set of circumstances in a given municipality. A number of parameters can be varied to simulate possible strategies including the reduction of phosphorus in detergents and the requirements for pretreatment of industrial wastes. Predicted changes in population and growth rate can be handled by the model which also accounts for future additions to plant capacity attributable to the requirement for phosphorus removal.

The remainder of this report is divided into a number of sections as follows: In Section IV the various strategies used to control phosphorus are discussed, Section V is a review of the treatment alternatives available to a municipality including methods which may not be feasible at the present time but show some promise, and Section VI is a description of the phosphate removal strategy and cost model. Section VII presents three case studies we have selected to illustrate how the model can be used by local communities. Section VIII includes the instructions for using the model along with a complete listing of the program. The program listing is fully documented with comments which reference constants and program variables including their source.

SECTION IV

PHOSPHORUS CONTROL STRATEGIES

The primary purpose of this report is to investigate the costs of various strategies for removing phosphorus from the effluents of municipal wastewater treatment plants. We must assume, therefore, that a decision has been made to reduce the input of phosphorus as a result of a desire to curb "cultural eutrophication".

Although our effort is concerned with only the reduction of phosphorus through treatment plants, several working groups including researchers at Utah State University under EPA sponsorship and Case Western Reserve University under a grant from the Rockefeller Foundation are investigating the overall implications of phosphorus cycling in the environment. Their work will presumably include an investigation of the relative quantities of phosphorus introduced through both point and non-point sources and the rate of release of phosphorus from previously deposited bottom sediments. Results of these studies may affect future eutrophication control strategies, but for the present we are assuming that a major reduction can be achieved in the pounds of phosphorus passing daily through sewage treatment plants.

Basically, the three available strategies for reducing or preventing the impact of phosphorus discharges on lakes include:

1. Removing phosphorus from wastewater by upgrading present treatment facilities.

2. Reducing the phosphorus content in raw sewage through legislation and enforcement.

3. Diverting wastewater treatment plant effluents around eutrophic receiving waters or to other waters which have adequate assimilative capacity.

These basic strategies are influenced by a number of factors including:

a. The implementation or non-implementation of local legislation limiting phosphorus content in detergent products.

b. The present status of local treatment facilities including type of treatment, sludge handling capability, excess capacity and degree of over or underloading.

c. Type of waste treated including ratio of domestic to industrial wastewater and classification of industrial waste.

d. Future growth of the community served and possible regionalization of treatment in the near future.

e. Status of plans for upgrading present facility, or constructing new facilities for reasons other than phosphorus removal.

f. Availability of alternate receiving waters where phosphorus bearing effluents may be diverted and be assimilated without adverse effects.

g. Regional factors such as climate, cost of chemicals, land costs, and transportation.

Legislation to Limit Detergent Phosphorus

The absence of a national regulation on the concentration of phosphorus in detergents together with local regulations passed by more than five states and 50 local governments has led to both a marketing problem on the part of the detergent manufacturers and an enforcement problem in the affected communities. In Canada, the government has instituted phosphorus controls on both the detergent manufacturers and the treatment plants. Phosphorus concentrations in detergents will be limited to no more than 5 percent after December 31, 1972 (1). As a result, many of the detergents distributed in Canada now contain 10-12 percent NTA which is presently banned in the U. S. (2). Some recent work has shown that NTA is completely biodegradable (3), although it apparently is still unacceptable for medical reasons. Other phosphate substitutes have tended to be highly alkaline and corrosive. Work is continuing, however, at an accelerated pace by the major detergent manufacturers. Proctor and Gamble has reported expenditures on the order of $85 million (4) to both reduce phosphates in detergents and test the substitutes for safety and effectiveness. Colgate-Palmolive early in 1971 reduced phosphate content of all its detergent products to less than 35%.

As the detergent manufacturers voluntarily reduce phosphate concentrations in their products, the enforcement costs on the local level should decrease and will eventually not be a significant factor.

Upgrading of Treatment Facilities to Include Phosphorus Removal

The present status of waste treatment within local communities will have a significant affect on the strategy for removing phosphates.

As we will discuss in the next section, chemical precipitation methods of removing phosphorus are easily implemented and are effective for 80 to 98% removal. These same techniques can also be used to improve BOD and suspended solids removal in plants which are presently overloaded. The cost of implementing the techniques will, among other factors, depend on the present chemical dispensing and mixing facilities, capacity of clarifiers, sludge handling facilities and ultimate disposal of sludge. Some treatment plants in smaller communities are operated on the extended aeration principle which requires relatively little sludge handling capacity. In other towns aerated lagoons may provide equivalent secondary treatment but do not provide adequate sludge handling facilities. The addition of phosphorus removal requirements in these towns would require relatively major funding for both construction and operating costs.

The 1968 inventory of municipal waste treatment plants (5) showed that more than 90 percent of the plants constructed were designed for wastewater flows of less than 5 MGD. A majority of these plants were designed for secondary treatment using either trickling filters or activated sludge. Most of these plants do not presently provide for any nutrient removal beyond the residual which in the case of phosphorus is on the order of 20 to 30 percent. In many of these areas the percentage of phosphorus in the wastewater due to the use of detergents may vary over a range of 40-75 percent depending on the classification and quantity of industrial wastewater treated. In towns near the high end of this percentage range where there is a minimum infiltration of sewer systems, the regulation of detergent phosphate will have a major effect on any decision to remove phosphorus by treatment.

Later in this report we will see that the major cost elements in upgrading treatment plants for phosphorus removal are the cost of chemicals, and the additional sludge handling facilities required. Recent controversy over the costs of phosphorus removal have been centered on the issue of whether or not the use of designed excess capacity in local plants could be used for phosphorus removal. In general, if excess capacity is provided, the capital costs for phosphorus removal are calculated on the assumption that this capacity is available. The operation and maintenance costs, however, include the overall increased effort necessary to operate the plant. These assumptions are discussed in greater detail in Section IV.

Effluent Diversion

We have briefly alluded to the impact on present waste treatment facilities of population growth rates and possible regionalization of treatment facilities. Section 208 of the Water Quality Amendments of 1972 addresses the issue of areawide waste treatment management. Regional development and implementation of areawide waste treatment management plans is encouraged by the government.

In the development of strategies for controlling phosphorus we are faced with the question of how to determine the future life of local plants and the impact of regionalization. Our model at the present time is designed for a single plant with all the peripheral decisions of how to upgrade that facility. With some modifications it could be designed to handle the same problem for regional organizations. Often a local community will have little choice in determining what water body will receive its treated effluent. Regional organizations would have a wider choice, thus effluent diversion becomes a viable alternative to phosphorus removal by treatment. In some temperate areas spray irrigation may also be a possibility and where facilities are regionalized and land is available this choice may be a logical one.

Effluent diversion as a stretegy requires a major effort in planning and construction. The Lake Washington diversion project in Metro Seattle is an excellent example. The comprehensive plan for the removal of all treatment plant discharges from Lake Washington was approved in October, 1958. The first ten year stage of the program required an outlay of \$125,000,000 (6). Some revisions and additions have added another \$20,000,000 to the project which has results in the removal of all treatment plant discharges from Lake Washington and the abandoning of all the ten treatment plants located on its shores. New interceptors were constructed and several large treatment plants were provided with effluent discharge into the Duwamish River or through deep outfalls to Puget Sound.

In the case of Lake Washington conditions improved markedly. A decision was made to divert rather than treat. If the regional mechanism had not been approved, the planning for any alternative other than treatment would not have been possible.

In the consideration of effluent diversion as a strategy the major cost elements are piping and pumping. Distance to the receiving body and topographic features control these costs. The problem becomes more complex, however, when the economics of scale of building large regional plants are combined with the costs of piping and pumping influents over large distances. As in the case of Lake Washington and Metro Seattle, the final solution most likely will involve a consolidation of facilities but is unlikely to involve one very large treatment plant serving a large area.

A number of optimization studies have been made on the problem of minimizing cost of treatment along river systems receiving waste treatment effluents. A recent report (7) discussed the optimum number and location of treatment plants and uses as an example the optimum design of a regional wastewater treatment system for the Merrimack River Valley. The program assumes that liabilities such as treatment plants now in operation and effect of combined sewers can be disregarded. The method chosen specifically treats the trade-off between the number of treatment plants and the extent of sewer systems. In another recent publication (8), a computer program has been developed to provide design data and the cost breakdown for regional sewer systems. The program takes the specified characteristics for the conveyance and designs a pipeline which minimizes the cost of conveyance for that particular situation.

An effluent diversion strategy would employ both elements mentioned above. The optimum number of treatment plants would be an element of the problem together with the minimum cost of piping and pumping the effluent. Since this strategy depends on a regional approach, we have not made specific provisions for it in our program. A subroutine could easily be added if required.

SECTION V

TREATMENT ALTERNATIVES FOR REMOVING PHOSPHORUS FROM WASTEWATER

The objective of this study has been to develop a computer program which would provide a given community with a means for evaluating various phosphorus control strategies and their associated costs. To accomplish this objective it was essential that existing phosphorus control technology be examined and that methods be selected which at best could be implemented immediately and at worst in the very near future at existing waste treatment facilities. These methods would then become the treatment schemes or options available to the community.

Inherent in the selection of available process options is a knowledge of needed design parameters. While specific values of design parameters may change with advancements in technology and more reliable measurement of actual field performance, the current "best estimates" are the minimum required. Obviously, the computer program provides for updating of design parameter inputs as better system knowledge is obtained.

A review of recent literature is presented in this section in an effort to justify the selection of present phosphorus removal options deemed acceptable for immediate implementation. Although there have been innumerable studies of phosphorus control technology, only those most recent studies relating to practical application, i.e., feasibility, pilot plant and demonstration studies are of interest herein.

Based upon this review, chemical precipitation was selected to be the most widely accepted means of removing phosphorus. Because chemical precipitation provides many alternatives (both of chemicals and application points) a discussion follows the literature review in which the specifics of each process option are presented.

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LITERATURE REVIEW

CHEMICAL PRECIPITATION SYSTEMS

Points of Application and Expected Phosphorus Removals.

The most commonly employed points of application are:

> 1) the primary clarifier (in either conventional or physical-chemical systems), 2) the aeration basin, 3) the secondary clarifier and 4) the chemical flocculation unit in a tertiary treatment system.

Removals of phosphorus in primary clarification can be achieved with any of three cations: Aluminum (Al^{3+}), Calcium (Ca^{2+}) or Iron (Fe^{2+}, Fe^{3+}). The most common forms in which these cations are added are shown below:

Alum
Sodium Aluminate
Lime
Ferrous Chloride, Ferrous Sulfate
Ferric Chloride, Ferric Sulfate

The chemistry of aluminum and iron reactions with phosphorus are similar. Both can be postulated on the basis of a precipitation reactions involving the formation of aluminum phosphate or ferric phosphate, and additionally the formation of aluminum or ferric hydroxide. The chemistry of these reactions is actually quite complex, serving in part to explain the difficulty accompanying the estimation of required cation dosages. The use of the reduced form of iron (ferrous) is prompted by the availability of pickle liquor (prinipally ferrous sulfate) a waste product of steel mills. Although oxidation to Fe^{3+} does occur, it is also possible for ferrous phosphate to precipitate.

The addition of calcium in the form of lime results in precipitation of hydroxyapatite, $Ca_{10}(PO4)_6(OH)_2$, as well as calcium carbonate, $CaCO_3$, and possibly magnesium hydroxide $Mg(OH)_2$ at very high pH. The chemistry of calcium addition is also complex. In fact, recent studies by Ferguson and McCarty (1) and Jenkins, et al (2) indicate that precipitation of phosphorus can occur at neutral pH conditions when calcium is added in forms other than lime.

In comparing these three cations, aluminum, calcium and iron, it may be noted that both aluminum and iron are added as salts of common anions (SO_4^{2-} and Cl^-), while calcium is added with hydroxide ions. Thus, aluminum and iron contribute anions to the wastewater which may be of concern in the future when water re-use becomes more prevalent (3). In contrast, lime adds only calcium because the hydroxide ions can be easily neutralized in later stages of treatment.

Chemical addition to the primary clarifier has both advantages and disadvantages. In addition to removing phosphorus, chemical precipitation also enhances both removal of BOD (biochemical oxygen demand) and suspended solids. As estimates, the removal of BOD has been shown to increase from the standard value of 30 per cent to about 60 per cent. Similarly suspended solids removal increases from 70 per cent to a maximum of about 90 per cent (4). These additional removals could provide a measure of relief to overloaded secondary facilities.

On the other hand, because hydrolysis of complex organic and inorganic phosphorus compounds is incomplete prior to biological treatment, the expected final effluent phosphorus concentration is quite variable and significantly higher than that achievable in tertiary phosphorus removal. In a review of data available from pilot plant and full-scale testing, Minton and Carlson (5) report the results of ten researchers and indicate effluent phosphorus concentrations ranging from 0.15 to 2.3 mg/l. The lower values, however, were only obtained after filtration. This indicates that some phosphorus was not readily precipitated or that insoluble phosphorus escaped due to deficiencies in clarification design.

Both aluminum and iron dosages can be expressed as a concentration ratio of cation to phosphorus (Al/P or Fe/P). Earlier research results were reported in terms of per cent phosphorus removal. However, it was recognized that the phosphorus content of wastewaters is quite variable both at a given plant and from plant to plant. Thus, to specifically state the chemical requirements, a cation/phosphorus ratio is needed. Again, just as effluent phosphorus values were shown to be quite variable, so too were the cation/phosphorus ratios as indicated by the data reviewed by Minton and Carlson (5). The weight ratios of aluminum to P for two studies were 1.5 and 3.4 while that of three studies of iron were 2.8, 3.1 and 5.8.

The addition of aluminum as alum will depress pH and may necessitate the addition of base in a low alkalinity water in order to maximize phosphorus removal. Added as sodium aluminate, pH will tend to increase which may displace the precipitation reaction from the optimal pH. This is especially of importance in primary clarifiers where axial dispersion is slight thus assuring increased pH near the point of application (5). Hence the addition of sodium aluminate to primary clarifiers is not recommended.

In wastewaters of low alkalinity (less than 150 mg/l as $CaCO_3$), the addition of lime will increase pH to values greater than 11 before adequate phosphorus removal is obtained. This implies that recarbonation, or some other form of pH adjustment will be necessary prior to biological treatment. On the other hand, wastewaters of higher alkalinity will provide a buffering capacity sufficient to prevent the pH from increasing above about 10 while achieving the required phosphorus removal. Moreover, these wastewaters usually contain significant carbonate alkalinity which enables co-precipitation of $CaCO_3$ thereby enhancing the settleability of hydroxyapatite. However, if wastewaters have high alkalinity but low hardness (calcium and magnesium), then co-precipitation may not prevail (3).

Lime treatment of raw sewage result in similar variations in effluent phosphorus as observed for aluminum and iron treatment. Examination of extensive field data from a full scale test at a 2.0 MGD plant in New Market, Ontario (6) indicate an effluent phosphorus of 2.0 mg/l with a lime dosage of 200 mg/l $Ca(OH)_2$. In another full scale test at Newport, Vermont (7), 80 per cent removal of phosphorus (effluent concentration unspecified) was only achieved at dosages greater than 400 mg/l (as $Ca(OH)_2$). The City of Rochester (8) will employ lime addition to primary clarifiers and this will be followed by the activated sludge process. A dosage of 125 mg/l $Ca(OH)_2$ is expected to produce a residual soluble phosphorus of 2 mg/l at a pH of about 10.0. A three month plant scale investigation at Richmond Hill, Ontario indicated that a lime dose of 175 mg/l produced a pH of 9.3 and a 83 per cent removal of phosphorus. Plant effluent phosphorus was stated to be 0.9 mg/l (9).

From review of various studies on lime addition to the primary clarifier, it may be concluded that the dosage of lime is directly related to alkalinity. Higher alkalinities require higher lime dosages to achieve a given pH. In fact, lime dosing is independent of influent phosphorus concentration and dependent on alkalinity and operation pH (10).

As a practical lower limit, wastewaters having alkalinity less than 150 mg/l as $CaCO_3$ are not suitable for lime treatment because pH will increase to levels greater than 10.0 before effective phosphorus removal occurs, and this will be unacceptable if biological treatment follows. To distinguish the lime dosage required for moderate alkalinity (150-300 mg/l as $CaCO_3$) from that for high alkalinity ($>$ 300 mg/l as $CaCO_3$) wastewaters, two levels of lime dose will be assumed; moderate alkalinity requires 150 mg/l, while high alkalinity requires 200 mg/l. Further, based upon field studies the achievable total unfiltered effluent phosphorus is estimated conservatively to be 2 mg/l.

Although lime will be later shown to offer advantages in sludge handling, consideration must also be given to solids recycle and prevention of excessive scaling (3). This may require modification of the primary clarifier. Lime recovery is not possible if lime is added to the primary clarifier because of excessive amounts of contaminants present in the sludge. Moreover, special consideration should be given to locations where anaerobic digestion is used for sludge handling. As will be discussed in later sections, lime sludge could cause digestor problems.

The combined biological-chemical removal system provides a method of improving secondary sludge handling characteristics while simultaneously removing phosphorus. As pointed out by Minton and Carlson (5), use of this system also implies that careful consideration be given to sludge wastage, maintenance of the culture and satisfactory floc formation (secondary clarification).

Sludge wastage will control the build-up of inorganic precipitates in the aeration basin. If build-up becomes significant, then a higher level of solids will be needed. Survival of the culture may be a factor if the dosage of aluminum or iron salts depress pH excessively. For example, although BOD removal may still be unaffected, the rate of nitrification may be reduced during severe pH depression (11). Satisfactory floc formation is related to the production of biological floc in removing chemically precipitated phosphorus. Polymers may be needed to assist in achieving good settleability.

Minton and Carlson (5) list results of eight studies of alum, seven of sodium aluminate and three of ferric chloride for removal of phosphorus in a biological-chemical scheme. Effluent total phosphorus values range from a low of 0.5 mg/l to a high of 6.8 mg/l. These authors further suggest that without the ability to remove insolubilized phosphorus, final effluent concentrations can be expected to exceed 1.5 mg/l. With the addition of filtration as a tertiary step, residuals of 0.5 mg/l can be achieved.

Minton and Carlson (5) also list the cation/phosphorus ratio used in each investigation. For alum, this value ranged from 0.8 to 2.1; for sodium aluminate, from 0.7 to 1.2; for ferric chloride, from 2.3 to 6.7. Similar results are listed in the EPA Process Design Manual on Phosphorus Removal (9). Based on these reports, it was concluded that the weight ratio of Al/P be estimated as 1.5/1 and that of Fe/P as 4/1.

Sodium aluminate should be added in the aeration basins because axial dispersion will prevent excessive pH rise. This chemical may be of interest in wastewaters of low alkalinity. However, it has been suggested that other means of controlling pH, namely adding a base such as soda ash or sodium hydroxide, should be used in conjunction with alum, thus avoiding the use of sodium aluminate (5, 9). In contrast to the application point of sodium aluminate, it is recommended that alum and ferric iron be dosed to the effluent channel of the aeration basin (5, 9). Minton and Carlson (5) state that turbid effluents have often been associated with cation dosing to the aeration basin itself, possible because of formation of poorly settling cation-hydroxide precipitate.

Pickle liquor, containing iron in the ferrous form, can be a convenient and inexpensive precipitating chemical. If the dose point pH is greater than 7, ferrous ion will be advantageous because ferrous hydroxide is much more soluble than either aluminum hydroxide or ferric hydroxide and thus not detract from settleability. Studies performed by the Detroit Metro Water Department (12) and the Milwaukee Sewerage Commission (13) indicated that pickle liquor provided satisfactory removal of phosphorus when added to the aeration basin. The addition of pickle liquor should be made at the head of the aeration basin to allow time for oxidation of Fe^{2+} to Fe^{3+}. Jenkins, et al. (2), however, point out that ferrous phosphate may also precipitate.

Although investigated to a lesser extent, the addition of calcium in forms other than lime has been postulated as another phosphorus removal alternative (1, 2). In wastewaters low in magnesium and carbonate, precipitation of $Ca_3(PO_4)_2$ will occur at pH of 8. Hence, calcium could be added to the aeration basin without causing the excessive pH elevation associated with lime. Jenkins, et al, (2) further suggest that solids recycle will enhance the rate of calcium phosphate precipitation. In fact, these researchers have reasoned that this mechanism may account for high phosphorus removals presently achieved at specific activated sludge plants that are not adding any precipitating chemicals. At the present time there is, unfortunately, no pilot or full-scale plant data to substantiate the success of this process alternative.

In trickling filter plants, chemicals should not be added ahead of the trickling filters (3, 9). Rather, chemicals should be added to the inlet of either the primary clarifier or secondary clarifier. Because of the many different recirculation schemes in use, Cecil cautions that chemical addition after trickling filters be only used where the recirculation pattern is filter outlet to primary clarifier inlet, or secondary clarifier outlet to primary clarifier inlet (3).

Based on limited data presented in the EPA Process Design Manual on Phosphorus Removal (9), the weight ratios of Al/P and Fe/P were determined to be 2.0/1 and 3.5/1 respectively for trickling filter systems. The achievable effluent phosphorus remains the same as that of chemical addition to the aeration basin or primary clarifier, i.e., 2 mg/l.

Tertiary treatment systems include both filtration after chemical addition to the aeration basin, and addition of precipitating chemicals in a tertiary step followed by filtration. As mentioned previously, chemical addition to the aeration basin together with a final filtration step after secondary clarification can remove insoluble phosphorus such that the final effluent phosphorus concentration is reduced to 0.5 mg/l.

Lime addition in tertiary treatment has been investigated to the greatest extent, perhaps as result of the demonstration project at Lake Tahoe (14). Although capital expense is largest in a tertiary facility, the effluent phosphorus concentration can be reduced as low as 0.1 mg/l. This is a factor of twenty lower than that achievable with either addition to the primary or secondary system. In addition, lime treatment at this application point enables lime recovery to be practiced.

In tertiary treatment using lime, the extent of pH elevation is determined by the alkalinity. Thus, moderate to high alkalinity ($>$ 300 mg/l as $CaCO_3$) require a dosage of lime sufficient to raise pH to about 9.5-10. Prior to discharge, recarbonation must be used to reduce the pH to an acceptable level. This is referred to as single stage recarbonation because chemical flocculation is followed by clarification and then recarbonation prior to filtration. Lime dosage is difficult to predict as a function of alkalinity (9). However, as a "best estimate", for alkalinities between 150 and 300 mg/l as $CaCO_3$, a lime dosage of 200 mg/l (as $Ca(OH)_2$ is required. Alkalinities greater than 300 mg/l as $CaCO_3$ will require 265 mg/l (as $Ca(OH)_2$). Without filtration, the expected effluent phosphorus concentration is 1.0 mg/l. With filtration, it is 0.5 mg/l.

In contrast, the pH of wastewaters of low to moderate alkalinity (less than 200 mg/l as $CaCO_3$) will increase to values greater than 11 before the lime dosage produces satisfactory phosphorus removal. Because of the low fraction of $CaCO_3$ formed in low alkalinity waters, floc will settle poorly. Thus a two stage recarbonation process is selected for production of more $CaCO_3$ precipitate and for depression of pH to the required final effluent value. This process therefore consists of chemical flocculation, clarification, firststage recarbonation (to pH of about 10.5), clarification, second-stage recarbonation (to pH of about 7.5) and finally, filtration. Again, as a "best estimate", a lime dosage of 400 mg/l is required for wastewaters of low alkalinity ($<$ 150 mg/l as $CaCO_3$) while a lime dosage of 530 mg/l is required for moderate alkalinity (150-250 mg/l as $CaCO_3$). Experience with this process is better documented than single stage recarbonation. Hence, the achievable effluent phosphorus concentration is estimated to be 0.1 mg/l rather than 0.5 mg/l.

The addition of aluminum in a tertiary scheme can also produce a lower final phosphorus concentration than either addition to the primary or secondary system (9). On the other hand, iron salts are less desirable because of residual iron remaining in the treated water. Minton and Carlson (5) summarized the findings of five researchers investigating alum in pilot-scale tertiary treatment. Filtered effluent phosphorus values ranged from 0.05 to 2.3 mg/l. Unfiltered effluent phosphorus ranged from 0.27 to 3.0 mg/l. The EPA Process Design Manual for Phosphorus Removal (9) suggests that with proper operation, effluent phosphorus can be reduced to 0.1 mg/l with filtration and 1.0 mg/l without filtration (but with polymer addition).

Unlike lime, the recovery of alum has not been shown to be practical. Hence, alum addition could only offer an advantage where local costs of alum are low enough to offset the costs associated with the more complicated single and two stage lime treatment system.

Quantity of Sludge Produced

Wastewater treatment plants precipitating phosphorus by chemical addition increase the amount of sludge to be handled. The quantity of sludge produced is dependent principally on the type and dosage of precipitant used. To obtain a first estimate of the additional sludge mass to be produced by chemical addition, calculations may be made based upon the stoichiometry of the chemical reactions involved. This approach has been illustrated for the case of iron addition to raw wastewater in the EPA Process Design Manual on Phosphorus Control (9).

Due to practical factors, stoichiometric equations can only be used as a rough guide to sludge production. The nature of chemical precipitates and their ability to be captured in sedimentation basins, for example, are affected by many variables which cannot be adequately treated in a theoretical approach. In the case of lime coagulation, the actual composition of the calcium precipitates is not even definitely established. Hence, it is more reliable to employ actual data from pilot plant or full-scale testing to predict sludge production from chemical precipitation.

Available data on sludge production from phosphorus removal systems is limited, but some values have been reported. A review article by Adrian and Smith (15) contains data obtained from 13 case histories. Tabulations of sludge quantities and densities are presented for calcium, aluminum, and iron addition at various points in treatment systems. Similar data has been presented by VanFleet et al (6), who documented six recent case histories in Ontario. The EPA Process Design Manual (9) also includes data on sludge production at several locations. Other data on sludge volume produced by chemical precipitation systems has been reported by Schmid and McKinnery (16) and Jenkins, et al. (2)

Sludge Handling

At the outset of phosphorus removal investigations, little attention was given to the ultimate fate of precipitated phosphorus. Although there is still very little plant operating data available, recent studies have dealt more fully with this crucial aspect of phosphorus removal.

In many existing plants, anerobic digestors are used for stabilization of both primary and secondary sludges. Two factors are important to the success of chemical precipitation in such facilities. First, the cation associated with phosphorus removal must not interfere with sludge digestion, and second, phosphorus resolubilization should be minimal.

Studies by Grigoropoulos, et al (17) have shown that neither alum nor sodium aluminate (both added to the aeration basin) were detrimental to digestor performance. Further, these researchers concluded that precipitated phosphorus was not released to the supernatant during digestion. In fact, phosphorus present in the primary sludge was also removed. Similar findings were reported by Thompson (7).

In full-scale testing, Van Fleet, et al. (6) reported recently that increasing the alum dosage above 150 mg/l caused a drop in digestor temperature and gas production. However, below a dosage of 150 mg/l, digestion appeared unaffected.

Malhotra, et al (18) demonstrated that iron phosphate precipitates behaved differently than aluminum phosphate precipitates. Primary sludges, with or without iron (ferrous) precipitated phosphorus indicated a significant uptake of phosphorus during digestion. A similar observation was noted by Thompson (7). In contrast, waste activated sludge containing mostly ferric phosphate released phosphorus upon digestion. The solubility of ferrous phosphate is greater than that of ferric phosphate and could, as the authors point out, account for the release of phosphorus when the waste activated sludge is anaerobically digested. The work of Singer (19) confirms this postulation.

It may also be noted that in the event of phosphorus release to the supernatant, recycle to the primary clarifier would only require that a greater dosage of precipitating chemical be used (18). Economic operation, however demands that supernatant release be minimized.

In full-scale tests at nine small activated sludge plants in Zurich, Switzerland, addition of iron chloride to the aeration basin had no noticeable effect on sludge digestion (20).

Sludge handling of lime precipitated phosphorus by anaerobic digestion can cause difficulty if the pH of sludge is greatly elevated. However, Van Fleet, et al (6) reported that holding of the lime sludge to a depth of one to two feet in the primary clarifier has solved this problem in a full-scale test.

In addition to anaerobic digestion, the Ontario Ministry of Environment (6) has provided the results of full scale testing at several facilities where vacuum filtration is in use. Anaerobic digestion at six activated sludge plants using various chemical precipitation options and vacuum filtration at three other plants have been studied.

Tables 1 and 2 summarize the data that is currently available from these investigations. The increase in sludge volumes as a result of chemical precipitation confirm to some extent "the rule of thumb" which states that sludge production will double. This has been indicated in the EPA Process Design Manual on Phosphorus Removal (9) and as well by Minton and Carlson (5).

TABLE 1

Effect of Chemical Additions for Phosphorus Removal on Digestion (6)

Plant	Flowrate MGD	Chemical	Dose mg/e	Percent w/o p removal	Solids with p removal	Sludge w/o p removal lbs/MGD	Production with p removal
New Market (Activated)	2.0	Lime	200	3-4	10-11	1700	4900
Barrie (Activated sludge)	--	Alum	150	4.54	4.25	--	--
N. Toronto (Activated sludge)	7.5	Fuels	35	6	3	--	--

Table 2

Effect of Chemical Additions for Phosphorus Removal on Vacuum Filtration (6)

Plant	Flow Rate MGD	Chemical	Dose mg/l	% Solids to Filter w/o P removal	% Solids to Filter with P removal
W. Windsor (Primary)	24	Alum Poylmer	90 0.4	11.5	7.6
Little R. (Activated Sludge)	4	Alum	.50	6.2	5.7
Little R.	4	Lime	125	6.2	11.6
N. Toronto (Activated Sludge	7.5	$FeCl_3$	35	---	---

Table 2 --Continued

Plant	Filter Yield lbs/hr/ft^2 w/o P removal	Filter Yield lbs/hr/ft^2 with P removal	Filter Cake Solids w/o P removal	Filter Cake Solids with P removal	Sludge Production lbs/MG w/o P removal	Sludge Production lbs/MG with P removal
W. Windsor (Primary)	11.3	5.8	31.1	19.2	960	2160
Little R. (Activated Sludge)	5.2	4.6	----	15.9	1580	2440
Little R.	5.2	7.2	----	----	1580	2320
No. Toronto (Activated Sludge)	2.27	4.74	----	----	----	----

As noted in Table 2, alum sludges diminished vacuum filtration yields while both lime and ferric chloride sludges increased filter yields. In addition, alum sharply reduced the per cent solids of both the feed sludge and filter cake while lime increased these parameters.

In this same field study, chemical conditioning of alum sludges was found to be much more difficult at the primary West Windsor primary plant (chemical costs increased from $3.10 to $9.50 per ton of dry solids). In contrast, little difficulty was encountered with alum sludge at the Little River Activated sludge plant (chemical costs increased from $16 to $17.96 per ton of dry solids). Lime sludge actually reduced chemical conditioning costs from $16 to $11.14 per ton of dry solids.

Pilot plant studies of physical-chemical treatment at the Cleveland Westerly plant (21) included collection of sludge handling data. Using lime addition to the chemical clarifier, per cent solids ranged from 6 to 14 per cent. Both a vacuum filter and a centrifuge were investigated for dewatering of this chemical sludge. Depending upon influent per cent solids, vacuum filtration produced a cake containing from 14 to 36 per cent solids. Filter loadings varied from 3 to 19 lbs/hr/ft^2. Success at higher loadings was attributable to the addition of polymers (2 lbs per ton of dry solids). Centrifuging produced a cake solids ranging from 20 to 28 per cent at a rotational speed of 3500 rev/min. Polymer addition (1.2 to 1.7 lbs per ton of dry solids) was required.

Novel Modifications of Chemical Precipitation Systems

Sadek (22) has reported the use of sacrificial electrodes of either iron or aluminum to introduce the cation necessary for removal of phosphorus. This system offers the advantage of introducing only the cation. In addition, Sadek claims that the evolution of hydrogen gas at the other electrode can be used to promote flotation of suspended material in wastewater.

Only bench-scale testing of this unique method of chemical precipitation has been reported. Although these results were used to estimate process feasibility and costs, it is difficult to predict the future of electro-chemical cation generation without pilot plant data. Cecil (3), however, suggests that further work should be encouraged.

The moving bed filter concept has been pilot plant tested by Johns-Manville Product Corporation (23). This process is actually a tertiary treatment system consisting of chemical addition. clarification and filtration. A bed of sand is pulsed upward in an inclined filter vessel to contact chemically treated wastewater in a constant head tank. Filtered wastewater passes down through the sand-bed. The top layer of sand that has trapped chemical floc drops to the bottom of the clarifier (constant head tank) and is removed as sludge.

This spent sand is then clean and returned to the filter system while the wash water containing chemically precipitated phosphorus is removed for further sludge processing because floc-laden sand is replaced continually with fresh sand. Filtration need not be interrupted for backwashing.

Although the moving bed filter offers the advantage of continuous operation, it is a more complex system than conventional filtration. Moreover, removal of phosphorus should not be expected to be any more complete than in other chemical precipitation systems employing filtration. Hence, this system does not warrant consideration as a process option for immediate implementation.

Evaluation of Process Data

As pointed out by Minton and Carlson (5), the method of data reporting used by researchers investigating chemical phosphorus removal systems lacks uniformity. For example, because of the wide variation in reported biological removals of phosphorus, the cation/phosphorus ratio should always be based upon the phosphorus left to be removed chemically. Moreover, the distinction between total phosphorus residuals and filtrate phosphorus residuals is clouded by variations in filter pore sizes used by investigators. Of even greater concern, some studies have failed to report the basis on which effluent phosphorus is measured.

The variability in results is graphically depicted by Minton and Carlson (5) in a plot of total phosphorus and filtrate phosphorus as a function of the aluminum/phosphorus molar ratio. The data is widely scattered, making selection of a cation/phosphorus ratio difficult. These authors attribute inconsistencies in part to the lack of correlation with system pH.

Based on this assessment of data by Minton and Carlson (5) and information provided both by the EPA Process Design Manual on Phosphorus Removal (9) and a review article by Jenkins, et al (2) four levels of effluent phosphorus concentration were assumed to be achievable. These were discussed in an earlier section. To reiterate: addition of chemicals to either the primary clarifier or aeration basin (or secondary clarifier of a trickling filter plant) will result in a total phosphorus concentration of 2 mg/l; addition of chemicals to the aeration basin followed by clarification and filtration will reduce the effluent phosphorus concentration to 0.5 mg/l; and addition of tertiary chemical treatment will produce the lowest phosphorus concentration of 0.1 mg/l using lime and 0.3 mg/l using alum.

Although addition of chemicals to the aeration basin of conventional activated sludge systems has been discussed in detail, there is little process data available on chemical addition to extended aeration facilities. Because primary clarifiers are not usually included in this form of treatment, chemicals must be added to the aeration basin unless tertiary treatment is proposed. Several technical problems may arise in this system, primarily as a result of high per cent sludge recycle.

It can be postulated that extended aeration systems to which chemicals are added will show a continual increase in suspended solids. This could impede clarification, increase mixing requirements, and overload the sludge recycle system. Moreover, without sludge wasteing, pH depression caused by alum or ferric chloride addition could be severe. Undoubtedly, sludge removal will be required at much more frequent intervals than commonly encountered in extended aeration plants.

Ewing Engineering Company performed a plant-scale study of aluminum (both alum and sodium aluminate) and iron (waste pickle liquor) addition to an extended aeration facility (24). Mixed liquor suspended solids increased from 7000 to a maximum of 11,000 mg/l. Unfortunately, the period of time was not specified; however, it was less than six months. Because the alkalinity of the wastewater was high (400 mg/l as $CaCO_3$), pH remained between 6.8 and 8.2. Biological activity was not affected measurably by any of the chemical additions. However, solids production increased by about seven to eight pounds per pound of phosphorus removed. This increased the required sludge wastage by approximately 100 per cent.

From this brief study of extended aeration systems, it is apparent that a more careful analysis of chemical addition will be required before being implemented on a wide scale.

BIOLOGICAL PHOSPHORUS UPTAKE

All biological wastewater treatment processes require inorganic nutrients to sustain growth. Thus, it is not surprising that some phosphorus removal is noted in activated sludge and trickling filter systems. Nevertheless, it is difficult to consider this a technique that will provide a predictable and significant phosphorus removal. Most reports state that the expected phosphorus removal in a biological system amounts to about 2 to 3 mg/l at pH4. At San Antonio, Texas (Rilling Plant), Los Angeles (Hyperion Plant) and Baltimore, Maryland (Back River Plant), 90 per cent phosphorus removal was indicated. This prompted study by the EPA in 12 other activated sludge plants. All of these other plants showed erratic removals, with most indicating very little removal (4).

The luxury biological uptake theory put forth by Levin and Shapiro (25) to explain biological removals has been refuted by Mulbarger, et al (26) and Jenkins, et al (2). In fact, these latter two authors suggest that chemical precipitation of Ca_2HPO_4 with the proper range of pH and calcium concentration can account for a considerable increase of phosphorus removal beyond that characteristics of biological uptake.

Cecil suggests that biological removals of phosphorus cannot be predicted because the basic mechanism of uptake is not known (3). He recommends, however, that operating conditions be maintained carefully at specific activated sludge plants where biological uptake has been noted to be significant.

More recently, Levin, et al (27) reported on pilot plant studies in Washington, D.C. in which a controlled process for biological removal of phosphorus was evaluated. In this process, activated sludge withdrawn from the secondary clarifier enters a thickener and is held for up to 12 hours. During this time, anaerobic conditions develop and cause the release of phosphorus into the supernatant. Activated sludge, now, deprived of phosphorus, is returned to the aeration basin where luxury phosphorus uptake occurs. Supernatant from the thickener, containing a high concentration of phosphorus in a relatively small volume, is then chemically coagulated for ultimate removal of phosphorus.

Results reported by Levin, et al (27) were obtained over a relatively short time (two months). Further, the objective was somewhat limited to demonstrating process feasibility rather than optimizing design. Several key features of the process require further study. These all relate to process stability during sustained operation in which sludge characteristics could be affected by changing wastewater characteristics and flowrates. Although this study did evaluate to some extent variations in process loading, there is still a need for collection of data over a longer time period.

Sherrard and Schroeder (28) lend support to the luxury uptake theory with their stoichiometric calculations of cellular phosphorus. Cell residence time is, however, very critical to optimal phosphorus removal. At low cell residence times, cell growth rate is maximized thereby maximizing phosphorus removal. The initial ratio of organic matter to phosphorus was also shown by calculations to affect biological uptake efficiency.

It may be concluded that biological uptake cannot be put forth as a generally accepted means of phosphorus removal, but must rather be considered in conjunction with chemical precipitation (which may further be enhanced by chemical additions).

ACTIVATED ALUMINA

Activated alumina has been shown to remove phosphorus by a mechanism best described as a combination of adsorption and ion-exchange. In this process, removal of phosphorus causes exhaustion of the columnar bed of activated alumina through which wastewater is passed. The rate of exhaustion has been predicted by mathematical modeling using synthetic sewage and laboratory columns (29). In considering practical application of this process, the most critical parameters become 1) length of service provided by a given charge of activated alumina, 2) degree of difficulty in regeneration and 3) interference from other constituents of the wastewater, e.g., head loss in the bed and surface fouling.

Ames (30) reported the results of laboratory studies in which both synthetic sewage and secondary effluent were fed to a column charged with activated alumina. Using secondary effluent, a steady decline in phosphorus loading capacity was noted after each regeneration cycle. On Cycle I, 600 bed volumes were treated before significant phosphorus breakthrough occurred; however, only 200 bed volumes could be treated on Cycle V.

The regenerant solution was 1 molar NaOH. It was concluded that solids were precipitating in the column during regeneration thus reducing the efficiency of phosphorus stripping. An acid wash with HCl followed by regeneration with a molar NaOH renewed the phosphorus capacity close to that originally observed.

It should be noted that a carbon bed was used prior to the activated alumina column to prevent carryover of organics which had in previous runs caused a build-up of bacterial slime on the alumina. Thus, practical installation of this process as a tertiary treatment step would involve more than just an activated alumina column. Moreover, the regenerant solution must, of course, be further treated to remove captured phosphorus. Ames (30) suggests the use of lime in a typical chemical precipitation scheme. The advantage offered by this system is a much reduced volume. That is, while phosphorus is removed from 600 bed volumes of wastewater, the volume of regenerant to be treated is only about 20 bed volumes.

ION EXCHANGE

Most experience with ion exchange involves strong base anion resins in the chloride form. Eliassen et al (31) reported successful application of ion exchange following either flocculation and filtration or filtration alone. A conventional activated sludge plant would therefore require multiple tertiary units to achieve phosphorus removal.

Without pretreatment, resin fouling severely restricts exchange efficiency (31). Because regeneration becomes less effective after each cycle, periodic cleaning of the resin is required. Pollio and Kunin (32) in later studies reported similar results. Gregory and Dhond (33) confirmed Eliassen's finding regarding preferential exchange of sulfate. That is, after breakthrough of phosphorus, sulfate continues to be removed. Therefore, wastewaters high in sulfate limit the effective resin capacity for phosphorus and in addition, cause more chloride ions to enter the effluent water.

In column studies using secondary effluent, a breakthrough of less than 0.3 mg/l of phosphorus occurred after 100 bed volumes had been treated (33). Although excessive head loss due to clogging by suspended solids did not occur, Gregory and Dhond noted that this may be a serious problem in plants with poor secondary effluents. Organic matter was also removed by the exchange columns, but, for the limited number of cycles of operation in this study, phosphorus removal was not impaired as a result.

Economics and efficiency demand that regenerant volume be minimized. Gregory and Dhond (33) observed that about four bed volumes of regenerant were needed for every 100 bed volumes processed. The waste regenerant solution must then be disposed. For small volumes, evaporation may be practical. Larger volumes warrant precipitation for removal of phosphorus.

Gregory and Dhond (38) concluded that ion exchange for phosphorus removal was of only limited application due to economics. Specifically, they cited its use in instances where local situations demand a very high quality effluent; for example, discharge to a recreational lake. A low concentration of sulfate may also be considered to be essential to economic use of this process.

Envirogenics (34) investigated a combination resin/iron sorbing system for phosphorus removal. In these studies, a cation exchange resin (Amberlite 200) was contacted with ferric chloride such that the resin surface then held Fe^{3+}. Laboratory column studies indicated substantial phosphorus removal capacity. Regeneration was accomplished with 0.1 molar ferric chloride solution. The spent regenerant could, according to these investigators, be treated with lime for ultimate precipitation of phosphorus.

A relatively constant regeneration capacity was observed over ten cycles; however, an uneconomical amount of ferric chloride was required. A lesser percentage of resin regeneration was deemed essential for economic application of this process. The results of this study cannot be stated as conclusive because they were obtained from a small laboratory scale investigation and were not complete.

Reliable cost projections and actual operation of the system are impossible to predict from such limited information.

Finally, a similar study reported by Block (35) was aimed at conversion of a solid adsorbent to an anion exchanger. Exchangeable cations in vermiculite were replaced by aluminum ions. It was postulated that columnar operation would result in removal of phosphorus by an adsorption reaction involving aluminum ions on the surface of the vermiculite. However, it was found that phosphorus adsorption capacity was far below that required for economic operation and this process was subsequently disregarded.

SELECTION OF PHOSPHORUS REMOVAL SCHEME

As shown in the review of literature, phosphorus can be removed by chemical precipitation, biological uptake, chemisorption and ion exchange. The first technique has been repeatedly shown by laboratory, pilot plant, and full-scale testing to be the most successful approach. The other three techniques, while noteworthy, suffer both technological and economic drawbacks.

The phosphorus control schemes to be considered herein are restricted to chemical precipitation. However, this does not severely limit the treatment options available. Foremost, there are three cations which can be used: aluminum, iron, and calcium. These are generally added in the following rather inexpensive chemical compounds:

1. aluminum in alum or sodium aluminate
2. iron in ferric or ferrous chloride as well as ferric or ferrous sulfate
3. calcium in calcium hydroxide (lime)

In addition to a selection of chemicals, precipitation offers a choice of application points; the most commonly employed are addition to: 1) the primary clarifier, 2) the aeration basin, 3) the secondary clarifier, and 4) the chemical flocculation unit in a tertiary scheme.

Besides process flexibility, chemical precipitation offers the advantage of a minimal investment in capital equipment. Moreover, the type of equipment required is already used in water treatment practice, thus assuring reliability. Essentially, chemical precipitation does not involve new process technology.

Finally, in addition to phosphorus removal, both organics as BOD (biochemical oxygen demand), and suspended solids removals are enhanced. The process can therefore serve to upgrade existing plant efficiency.

Biological uptake, in contrast, has not been shown to be a reliable method of phosphorus control. Although demonstrated at specific activated sludge plants, there is little information on design factors of impact because there is not at present a clear understanding of the mechanism of removal. It may be concluded that more operational data must be obtained before this can be recommended as a practical method of phosphorus control.

Chemisorption is the technique or mechanism associated with the use of activated alumina for phosphorus removal. Although the exact removal mechanism is not understood, it is thought to be a combination of ion exchange and adsorption. There have been no reports of pilot plant or full-scale testing with activated alumina.

The chief technical disadvantage of the process is the requirement for regeneration of the alumina bed before exhaustion of phosphorus removal capacity.

Furthermore, the added complexity of another unit operation (packed beds of activated alumina) needs to be carefully considered in light of the inherent operational disadvantages associated with backwashing, bed fouling, brine disposal, and multiple-bed rotational schedules. Aside from technical drawbacks, the capital and operating costs of the process have not been fully studied.

In pilot plant studies of ion exchange, organic fouling led to reductions in regeneration efficiency after each cycle and limited the effectiveness of a given quantity of resin. Thus, in order for ion exchange to be successfully employed, it will be necessary to pretreat wastewater even after secondary clarification. The technical problems described above with regard to activated alumina equally apply to ion exchange. Consequently, unless several advanced waste treatment objectives are sought simultaneously, ion exchange cannot be considered as a practical means of phosphorus control.

Process Options

Both application point and chemical added provide options for a given community. These are summarized below and are represented schematically in Appendix A.

Option 1. Addition to the Primary Clarifier

Chemical Alternatives:

a. Alum + polymer
b. Ferric Chloride + polymer
c. Ferrous Chloride + Lime
d. Lime

Option 2. Addition to a Flocculation Basin Prior to Primary Clarifier

Chemical Alternatives:

Same as a, b, c, d above

Option 3. Addition to the Aeration Basin

Chemical Alternatives:

a. Alum
b. Ferric Chloride
c. Sodium Aluminate

Option 4. Addition After Trickling Filter

Chemical Alternatives

- a. Alum
- b. Ferric Chloride

Option 5. Option 3 or 4 plus multi-media filtration

Option 6. Addition of lime to a Flocculation Basin Following Conventional Secondary Treatment

- a. Single Stage
- b. Two Stage

Option 7. Addition of Alum or Ferric Chloride to a Flocculation Basin Following Conventional Secondary Treatment

In all of the above options, it is assumed that the plant is either already providing secondary treatment or is under an implementation schedule to construct these facilities. This means that the selection of phosphorus control schemes is not limited to Option 1 or Option 2 in an existing primary plant. Where secondary facilities do not exist, however, capital costs computed for phosphorus removal will include those items needed to acquire a secondary treatment plant.

INPUT DATA REQUIRED FOR PROCESS OPTIONS

General

In order to compute the costs directly attributable to phosphorus removal, the following technical information must be known for each process option:

1. Achievable Effluent Phosphorus Concentration
2. Chemical Dose(s) Required
3. Quantity of Sludge Produced
4. Density of Sludge Produced
5. Sludge Handling Processes to be used
6. Design Factors for Sludge Handling Equipment

These factors are discussed individually in the following sections.

Achievable Effluent Phosphorus Concentrations

Table 3 lists the four levels of phosphorus concentration estimated to be achievable with the specific control strategies listed. These levels are attainable throughout the range of influent phosphorus concentration normally found in municipal wastewaters. Although advantages for Option 3 over Option 1 have been cited, process reliability dictated that these be rated the same. The

Table 3

Achievable Effluent Phosphorus Concentrations

Level (mg/l as P)	Process Options
2	1, 2, 3, 4
0.5	5
0.5	6 (Lime, one stage)
0.1	6 (Lime, two stages)
0.3	7 (Alum)

addition of multi-media filtration (Option 5) provides removal of insoluble phosphorus, while tertiary treatment (Option 6) adds more process reliability and control and yields the highest quality effluents.

Chemical Dose(s) Required

For both aluminum and iron addition, the amount of cations required to achieve the effluent phosphorus concentration described above is proportional to the influent phosphorus concentration. A considerable variation in weight ratios was found from study to study for each cation. However, for the purpose of a phosphorus control strategy program, only a reasonable estimate is necessary. Table 4 provides the weight ratios selected for use for both aluminum and iron in all options.

Table 4

Cation/Influent Phosphorus Weight Ratios

	Options 1, 2	Option 3	Option 4	Option 5	Option 7
Al	2/1	1.5/1	2/1	1.5/1	2/1
Fe	3.1/1	4/1	3.5/1	4/1	

In addition to the cation of choice, polymer addition is also recommended at a level of about 0.5 mg/l.

In contrast to aluminum and iron precipitation, phosphorus precipitation with calcium depends upon the formation of more than one precipitate. That is, calcium carbonate along with calcium hydroxy apitite precipitation is considered essential to successful phosphorus removal. Moreover, a pH in the range of 9.5 to 11.5 is also required in most applications. Therefore, in most cases, lime [$Ca(OH)_2$] is used for calcium precipitation of phosphorus.

The amount of carbonate contained in a wastewater directly relates to the alkalinity of the water supply (and possibly to industrial contributors). At higher alkalinities, more lime is needed to reach a given pH because of the increased buffer capacity. In these waters, lime can be added to the primary clarifier in sufficient dose to provide phosphorus removal without raising the pH to an unacceptable level for subsequent biological treatment. On the other hand, waters of low alkalinity will reach a pH of 11 to 12 for the same applied lime dose. This would be unacceptable if biological treatment followed. Thus, the phosphorus control scheme provided herein considers lime addition to the primary clarifier (Option 1 or 2) to be valid only if alkalinity is greater than 150 mg/l as $CaCO_3$.

Similarly, in tertiary treatment, lime precipitation is influenced by alkalinity. High alkalinity waters permit single stage precipitation while low alkalinity requires two stages with the second stage providing re-carbonation to lower pH and precipitate calcium carbonate. An alkalinity greater than 200 mg/l has been selected for meeting the requirements of single stage treatment.

The addition of lime or other salts containing calcium to the activated sludge system (pH 7.5 to 8.5) was not considered herein. This process has been suggested by Jenkins et al (2) as an alternative phosphorus removal method in low alkalinity waters accompanied by low magnesium concentrations. However, little verification of this approach could be found from either pilot plant or full-scale testing programs.

Table 5 lists the lime dosages to be used in the various phosphorus removal options.

Table 5

Lime Dosages

Lime Dose mg/l as CaO	Option
150	1,2 Alkalinity 150-300
200	1,2 Alkalinity > 300
300	6 (Two Stage) Alkalinity < 150
400	6 (Two Stage) Alkalinity > 150
150	6 (Single Stage) Alkalinity 200-300
200	6 (Single Stage) Alkalinity > 300

Quantity of Sludge Produced

Table 6 lists the values selected to represent sludge production for each cation precipitant and process option. The values are based upon data given in the literature, employing engineering judgment where divergent results were reported. As more information becomes available, it will be possible to further refine these values. The numbers shown in Table 6 are incorporated in TSHEME subroutine of the model.

Table 6

Sludge Production

Cation	Option	Sludge Produced
Aluminum	*1,2	5.7 lb/lb Aluminum
	3	4 lb/lb Aluminum
	4	3.6 lb/lb Aluminum
	5	8 lb/lb Aluminum
	7	3.6 lb/lb Aluminum
Iron	*1,2	2.4 lb/lb Iron
	3	2.4 lb/lb Iron
	4	2.4 lb/lb Iron
	5	1300 lb/MG
Calcium	*1,2	3000 lb/MG
	6A(Single Stage)	3000 lb/MG
	6B(Two Stage)	7000 lb/MG

*Does not include sludge assumed from added removal of 50 mg/l suspended solids.

It may be noted that, although some estimates in Table 6 are expressed in pounds per million gallons, sludge production was related to pounds of cation added where possible to account for varying chemical dosages. Additionally, it should be pointed out the values presented represent only the additional chemical sludge produced by the precipitation process; they do not include, for instance, the additional incremental removal of organics that would be achieved by chemical addition to a primary clarifier.

Density of Sludge Produced

To define the exact magnitude of the additional sludge handling load at a treatment plant when phosphorus removal is instituted, the sludge density or per cent solids in the sludge must be stated. This parameter can directly affect the efficiency of sludge thickening and dewatering. In general, addition of iron or aluminum coagulants will cause a reduction in percentage solids resulting in a bulkier sludge and one which is more difficult to dewater. Lime addition, on the other hand, seems to produce a denser sludge while enhancing dewaterability.

Estimates of percentage solids in various chemical sludges produced by the different process options are given in Table 7. The values are based on limited information presented in the literature and should be updated as better data becomes available.

Table 7

Per Cent Solids of Chemical Sludges

Cation		% Solids
Aluminum	1, 2	3
	3, 4, 5, 7	1.5
Iron	1, 2 (Pickle liquor)	8
	1, 2	2
	3	1.3
	4, 5	1.5
Calcium	1, 2	5
	6A (Single Stage)	4
	6B (Two Stage)	3

One area of increasing interest regarding sludge production involves the use of pure oxygen in activated sludge and aerobic digestion systems. A recent pilot study on the use of oxygen in conventional activated sludge processing has shown that 40-45% less excess biological sludge is produced compared to conventional plug flow diffused air aeration (37). The economic studies indicate that as plant size increases, the costs with oxygenation become less than conventional diffused air. The authors projected savings of 20% for a 100 MGD design.

In regard to filtering characteristics in the same pilot study mentioned above, it was concluded that waste activated sludge from an oxygenation system can be vacuum filtered directly without thickening. Although studies of aerobic digestion were performed only on a batch basis, a stabilized sludge was obtained in 7-9 days with a 20-30% reduction in volatile suspended solids.

If the pure oxygen systems are used more frequently in the future, there will undoubtedly be a reduction in sludge handling costs which will in turn influence the cost of phosphorus removal. More information is required, however, on the reduction of chemical sludge resulting from phosphorus removal by precipitation and coagulation.

Sludge Handling Process Options

The overall purpose of sludge handling processes is to reduce the water and organic content of sludges. To accomplish this purpose, numerous types and combinations of processes may be used. The possibilities are so numerous, in fact, that for purposes of this study it is necessary to delineate only a few of the more typical sludge handling schemes. The schemes selected should, however, be representative, of most of those used in practice since process flow sheets for sludge treatment tend to follow similar arrangements.

The sludge handling options designated in this study are shown schematically in Appendix B and are summarized in Table 8.

Table 8

Sludge Handling Options

Option 1. Combined handling of all sludge by gravity thickening, anaerobic digestion, and mechanical dewatering.

Option 2. Combined handling of all sludge by gravity thickening, dewatering, and incineration.

Option 3. Same as Option 2, except that secondary (biological) sludge is thickened by flotation while primary and tertiary (if any) sludge is thickened separately by gravity.

Option 4. Combined handling of all sludge by gravity thickening, anaerobic digestion, dewatering, and incineration.

Option 5. Separate handling of tertiary lime sludge by gravity thickening, centrifugation, calcination, and slaking.

Additional options may be added in the future if experience warrants it.

Design Factors for Sludge Handling Equipment

In order to size sludge handling equipment, estimates of equipment performance with various types of sludge is needed. Again, little data is available. The loading factors developed for the various sludge handling processes are given in Appendix C. The values are based principally on data presented by Smith (36). Loading factors presented for vacuum filtration also incorporated the recent work of Van Fleet, et al (6).

SECTION VI

PHOSPHORUS REMOVAL STRATEGY AND COST MODEL

Use of Model

The phosphorus removal model, REMOVE, is an interactive simulation of the process of removing phosphorus from the effluents of municipal wastewater treatment plants. Included in the model are the interactions between phosphorus limiting legislation, upgrading of the treatment plant, changes in the population of the community, strength of the influent wastewater and the effluent objective to be achieved. The model evaluates for the user a number of strategies for achieving the effluent objective and presents least cost alternatives in terms of both unit cost and estimated total costs.

The three major strategies available to a community for the control of phosphorus include:

1. Legislation to limit phosphorus concentration in detergents.
2. Chemical methods for treating wastewater to remove phosphorus.
3. Diversion of phosphorus bearing effluents to receiving waters with greater assimilative capacity.

It is the basic function of the model to evaluate the interactive effects on cost for the first two strategies mentioned above. In the programmed version of the model we have not considered effluent diversion since this would require the availability of alternate receiving waters. This option might not be available to local communities although if regional groupings were considered the option might be viable. The model can be incorporated in a regional model if this is desirable. At the present time, the programmed version is suited to the evaluation of strategies and costs on the local level which might be, for example, the case of a medium-size community on the shores of Lake Erie, faced with decisions on whether to upgrade their present plant, limit industrial effluents, or pass legislation to limit phosphorus in detergent products sold in the community.

Model Description

REMOVE consists of a series of subroutines which correspond closely to the physical subsections of the phosphorus removal problem as shown in Figure 1. The flow chart for REMOVE, which is shown in Figure 2, corresponds closely to the major elements in Figure 1. In addition, each of the major subroutines is comprised of smaller subroutines which can be easily modified as additional phosphorus removal and waste treatment process data becomes available. REMOVE has been designed to manipulate variables contained in common blocks, therefore, many of the subroutines have no arguments because the heart of the program is contained in the common blocks.

The program has been written in Fortran IV and has been run on an IBM 360/67. A core size of 288K bytes is required for execution when the program is run in the interactive mode on a time shared system. With some modifications the program can be run in a "batch" mode with some reduction in core size.

REMOVE is designed to provide an estimate of the cost to a particular community of achieving a designated level of phosphorus removal. The program begins with the entry of data describing the community in terms of population and future trends, the treatment plant in terms of present size and excess capacity, and the influent wastewater characteristics. The data can be entered interactively through subroutine SYSTEM.

After input data has been entered, the user has the opportunity to investigate various control strategies for achieving a low phosphorus concentration in the wastewater effluent. Typically, the effects on cost of reducing phosphorus in detergent products, of increasing or decreasing the amount of government financing available, or of using various treatment options can be investigated.

From the description of the community, treatment plant, wastewater characteristics, and desired strategy the model will design a treatment plant incorporating the present plant as described by the user and will add those processes or additional equipment necessary to achieve the desired effluent level. The process options which will achieve particular effluent levels are described in Appendix A. Each process is sized according to relationships developed in Reference 10 and by our own work under this contract as described in Section V. The program converts the sizing information into construction costs, operating man-hours, maintenance man-hours, and total material and supply costs for each process. It is important to note that any increase in plant capacity dictated by the population growth of the community and not by the requirement for additional phosphorus removal is not included in the computed cost. This is achieved in the BUILD algorithm and subroutine which is described later.

The majority of the cost relationships for the processes and equipment included in the program were developed for EPA by Black and Veatch, Inc. (Reference 6). Costs representing a fixed percentage of construction and operating and maintenance were not included in the cost calculations. These costs, which include yardwork, legal, and administrative charges, may increase the total cost estimate for each phosphorus removal process by five to ten percent. The unit treatment costs on a cents per kilogallon of wastewater treated basis are computed and printed for each scheme. The user may refer to the unit cost as a rough indication of the "figure-of-merit" of a particular process scheme.

Modeling Considerations

The model has been developed as a simulation and as such does not achieve a mathematical optimization. The user is presented with least cost alternatives for various removal strategies and from these alternatives can optimize his/her decision.

The reader is referred to the Fortran program listing in Section VIII for the specific cost equations and sizing relationships chosen. The program is fully documented with comments and can be easily understood by readers with only a limited knowledge of Fortran programming. In this section we are presenting some of the basic considerations upon which the simulation is based.

Limiting the phosphorus concentration in detergents has a significant influence on wastewater phosphorus concentrations since almost 50% of phosphorus in wastewater appears to originate from the use of household detergents. This number can vary, however, and we have found that depending on the volume of non-household waste treated, the percentage can vary from 10-75%. If we assume p_c to be the current percentage of phosphorus in detergents, p_l to be new legislated percentages of phosphorus and N to be the total amount of detergent consumed by the sewered population per year, then:

$$N \cdot p_c \left(\frac{p_c - p_l}{p_c} \right)$$

is the total phosphorus reduction achieved by implementing removal legislation.

Assuming P_c is the current phosphorus concentration in wastewater, including sources other than detergents, then P_L as shown below is the concentration in the raw sewage which may be achieved by legislation assuming that W is the amount of wastewater treated per year.

$$P_L = P_c - N \cdot p_c \frac{p_c - p_l}{p_c} \bigg/ W$$

The cost to society of this legislation will be directly proportional to the cost difference for a new phosphate substitute detergent. We will assume that C_e is the cost of a new phosphate substitute detergent in dollars per unit weight of detergent and C_c is the current cost of a phosphate containing detergent. The cost to society of the new detergent will be:

$$C_L = N(C_e - C_c) = NC_s \; .$$

The differential cost C_s may also be the difference in cost between a high phosphate percentage detergent and a low one. In the computer model C_s will be called the DIFCOS. We are assuming in the development of this methodology that each detergent substitute will have similar cleaning power per unit weight and that C_s can be estimated for each town.

We might also add to the above cost, an enforcement cost E, covering for example, the cost of having officials enforce the legislation. This cost can be considered directly proportional to the community's sewered population, POP. When we include the enforcement cost, C_L becomes

$$C_L = NC_s + E(POP)$$

Equations for C_L and P_L are in subroutine DTGLIM of the model. The subroutines are listed in alphabetical order in Section VIII. Values for C_s and E have been assumed to be \$.02 and \$.40 respectively based on best available information. These values may be changed by the user and we expect that as phosphate substitutes become more widely accepted, both values will decrease as a result of greater market competition and a reduced enforcement requirement.

Chemical treatment methods as discussed in Section V are presently the only practical means of phosphorus control at the waste treatment plant. There are N x M treatment possibilities resulting from the choice of N chemicals (e.g., lime, aluminum, iron) at M points of application (e.g., primary, secondary, tertiary) within the treatment plant. Although two or more chemicals may be used in combination, it is usually not practical and we may consider chemical treatment as a single, discrete variable which we will call T. Each value T may assume represents one chemical treatment applied at one treatment stage including one value of T representing the option of no chemical treatment. Ideally, we would like to find a functional relationship between chemical dosage and phosphorus effluent level for each of the values of T. Unfortunately stochiometric relationships for chemical phosphorus removal treatments do not accurately predict the treatment plant results. In addition, only a limited number of experimental and actual phosphorus removal applications have been reported in the literature and those available give widely varying results. For these reasons we have found it impossible to develop a widely applicable functional relationship giving detailed descriptions of each procedure. Rather, we have established for each value of the treatment variable a maximum expected value for phosphorus concentration in the plant effluent. This value is called $P_{out}(T)$. A list of treatment options and the value of $P_{out}(T)$ is given in Appendix A.

The effluent phosphorus concentration will be given by:

$$P_{eff} = \text{min of } [P_L, P_{out}(T)]$$

In general, treatment will usually be required since a minimum P_L will generally be greater than 2 mg/l which is the maximum allowable effluent concentration in many locations.

A cost function relating the cost of chemicals, handling equipment and storage can also be defined. These costs will be designated by $C_T(T)$ and will include amortized equipment cost as well as the costs for energy, chemicals, and maintenance.

$$C_T(T) = C_{equip}(W) + C_{o+m}(W) + C_{mat}(p_I, \text{chemical})$$

The cost of chemicals will be a function of the level of phosphorus in the influent and this in turn is affected by the legislated level of phosphorus in detergent products. The dosing relationships for the various chemicals used in the phosphorus removal treatment have been discussed in Section V. The specific Cation/Influent phosphorus weight ratios used in the model and the lime dosages are summarized in Tables 4 and 5 of Section IV.

The addition of a chemical treatment scheme for phosphorus removal to an existing waste treatment plant will result in the production of additional sludge. The handling and processing of this sludge results in additional costs. The amount of additional sludge, which we will call $S(W, T, P_L)$, will be a function of the wastewater volume (W), the chemical treatment method (T), and the phosphorus concentration in the wastewater influent (P_L). The equations for determining the additional sludge produced are contained in subroutine SIZE and incorporate data presented in Table 6 of Section V. In this subroutine the size of equipment required to handle additional sludge produced as a result of both the phosphorus removal requirement and increased population are determined. P_L is a function of the detergent limiting legislation so that the amount and therefore the processing cost of additional sludge will depend on the legislation variable (p_l) as well as the treatment variable (T). The cost function itself will be a simple summation of amortized capital costs, operating and maintenance costs, and materials costs for various types of sludge handling equipment. This function will take into account the excess capacity of a plant and future growth of the community over a given time horizon. This cost function is represented by $C_{slge}(p_l, T)$:

$$C_{slge}(p_l, T) = C_{equip}(S) + C_{o+m}(S) + C_{mat}(\text{chemical}, S)$$

Equations for determining $C_{slge}(p_l, T)$ are contained in subroutine TRT2. Table 9 lists the cost functions together with their location in the program listing.

The costs attributable to phosphorus removal will depend on size relationships developed in SIZE and in the BUILD subroutine which determines whether or not excess plant capacity can be used, and if not, whether or not the plant expansion is chargeable to phosphorus removal or to increasing population.

Solid waste disposal assumes that there is at least one sink available with the capacity to accept the minimum amounts of solid waste output from the treatment plant. The capacity of each sink N is defined as $P_{ss}(n)$ and the cost of transporting the solid waste is a function of distance from the plant to the sink and is $C_{ss}(n)$:

$$C_{ss}(n) = C_{ss} \cdot \text{DIST}(n) \cdot S(W, T, P_L)$$

where C_{ss} equals unit transportation costs, and DIST(n) is the distance to sink n. The $C_{ss}(n)$ equation is contained in subroutine SSKCST.

Although the model is a simulation and not a linear programming model, we can define what might be called an objective function for phosphorus reduction. Cost minimization will result when values of the variables P_l (legislation), T (chemical treatment), and m (selection of sink) are in the right combination to minimize the total cost:

$$\text{Total Cost} = C_L(p_l) + C_T(T) + C_{slge}(p_l, T) + C_{ss}(n)$$

The minimization is carried out by the user interacting with the simulation model under the constraints that:

Table 9

COST FUNCTION LOCATOR

Cost Term	Name	Subroutine Location
C_L	Cost of Phosphorus Limiting Legislation	DTGLIM
$C_T(T)$	Total Cost of Liquid Treatment	TRT1
$C_{equip}(W)$	Amortized Cost of Equipment for Liquid Treatment	CONCST
$C_{o+m}(W)$	Operating and Maintenance Cost of Liquid Treatment	TRT1
$C_{mat}(p_1, \text{chemical})$	Cost of Chemicals for Liquid Treatment	TRT1
$C_{slge}(p_1, T)$	Total Cost of Sludge Handling	TRT2
$C_{equip}(S)$	Amortized Cost of Equipment for Sludge Handling	CONCST
$C_{o+m}(S)$	Operating and Maintenance Cost for Sludge Handling	TRT2
$C_{mat}(\text{chemical}, S)$	Cost of Chemicals for Sludge Conditioning	TRT2
$C_{ss}(n)$	Cost of Solid Waste Disposal	SSKCST

$$P_{eff} < P_{sink}(m) \text{ or } \min [P_L(p_l),\ P_{out}(T)] < P_{sink}(m) \text{ and}$$

$$\text{Solid Waste} < \sum_{n=1}^{N} P_{ss}(n)$$

In addition to the above alternatives and costs, we also considered effluent diversion as a possible strategy. Effluent diversion assumes that there are two or more sinks available wherein phosphorus bearing effluent can be routed. If effluent phosphorus concentration standards are different for the different sinks and if costs (piping, pumping, etc.) of bringing effluent to each sink differ, then it is possible to trade the cost of achieving lower effluent standards at one sink against the cost of routing the effluent to another. Assume that the effluent concentration standards for the M sinks are given by $P_{sink}(m)$ for the mth sink and that piping and pumping costs for routing the effluent to the mth sink are given by $C_{sink}(m)$. These costs include amortized capital costs as well as operating and maintenance costs for the required wastewater transportation equipment. Thus if sink m is chosen, then the effluent concentration must be at or below the ambient concentration $P_{sink}(m)$ and the cost incurred will be $C_{sink}(m)$.

Since effluent diversion in most cases requires a regional grouping of treatment plants it was not considered further in this program. It can be incorporated, however, and might be desireable in the planning of future treatment plant alternatives.

Subroutines

The model REMOVE consists of a series of subroutines which are the logical subsections of the model. The program is initiated with subroutine, SYSTEM, making inquiries of the user in order that a description of the community, the influent wastewater, and the current status of the treatment plant may be input in proper form to the program.

Next, STRTGY requests information on what time horizon and phosphorus effluent levels are desired by the user as part of the control strategy. The user may also indicate whether or not the effect of phosphorus limiting legislation is to be explored as a possible strategy.

The subroutine, LCHOSE, then implements an eligibility criteria algorithm to choose (and mark as eligible for a particular control strategy) those liquid treatment schemes which are able to achieve the given effluent level restrictions. The treatment schemes and their achievable phosphorus effluent concentrations are described in Appendix A. The algorithm will not select treatment schemes which achieve a much lower effluent concentration than the one desired. For instance, if the allowable effluent concentration is 2 mg/l, treatment schemes achieving effluent levels lower than 0.5 mg/l will not be chosen.

A loop is then entered and disposal costs are calculated for each of the treatment schemes selected. A long report may be printed for each scheme showing for each process within the treatment scheme the construction cost, amortized cost, year process is first needed, and the periodic operating costs. Several short report formats may also be selected which summarize cost information for each treatment scheme.

A number of subroutines enter into the above cost calculations. The subroutine, TRTMNT, first calls SCHOSE to select the sludge handling scheme most compatible with the input data describing the existing waste treatment plant. A list of the sludge handling schemes incorporated within the model is presented in Appendix B. SIZE is then called to compute for each time period of the control strategy the size of each piece of equipment (or process) required by the eligible treatment scheme with and without phosphorus removal being considered. BUILD then determines, based on the present size of equipment currently in the treatment plant, how much additional equipment will be needed, at what time, and whether or not the cost will be assessed to the phosphorus removal requirement. TRTMNT then calls SIZE again and computes the operating and maintenance costs, and material costs for each process required for each time period. SIZE is called at this time because some of the operating and maintenance costs depend on the design size as determined by BUILD and some on the actual operating time the equipment is used. After the O&M and material costs are calculated the construction costs are determined by CONCST. The flow chart for the computation of costs in TRTMNT is shown in Figure 12.

Subroutines, LSKCST and SSKCST, compute the disposal costs for liquid and solid effluent from the plant. LSKCST is not activated in the model at the present time since it involves the effluent diversion strategy. If it were to be activated, it would examine the maximum assimilative capacity for phosphorus for each of several possible receiving bodies of water and would select those sinks capable of assimilating the phosphorus effluent over the whole time horizon. It would then determine the sinks resulting in the lowest pipe and pumping costs. The effluent would be routed to those sinks with acceptable assimilative capacity and lowest piping and pumping costs. SSKCST chooses the lowest cost solid waste sink for each time period. To be eligible a sink must have sufficient capacity for the solids over the entire time period. The least costly eligible sink would be the one with the lowest transportation cost which generally would be the site closest to the treatment plant.

Finally, for each particular treatment scheme REPORT prints a summary of the costs. After printing the costs for one treatment scheme the program returns to compute costs for the next eligible scheme and continues until all eligible schemes have been costed.

After all treatment schemes eligible under a particular control strategy have been evaluated, the program will ask the user if another control strategy is desired. If so, the program variables are reinitialized and control returns to STRTGY. If not, the program is ended.

ASSUMPTIONS AND LIMITATIONS

Cost Data

The accuracy of cost predictions for each of the strategies evaluated by REMOVE depends to a large degree on the validity of sizing and cost data incorporated in the SIZE, CONCOS, and TRTMNT subroutines. Cost data for most of the processes and manpower requirements is from a study performed for EPA by Black and Veatch, Inc. (Reference 6). In several cases cost data has also been used from the COST2 computer program developed by Smith and Eilers (Reference 10) and the Process Design Manual for Phosphorus Removal (Reference 12). Comments incorporated in the subroutine program listing refer to the source of the particular cost equations.

All cost and labor data is keyed to standard indexes which update the cost data to the present time. The EPA "Sewage Treatment Plant Construction Cost Index", the U. S. Department of Labor "Index of Wholesale Prices and Prices Indices", and the Department of Labor "Employment and Earning Statistics" have been used for this purpose.

The information developed in Reference 6 for estimating costs and manpower requirements was intended to be applicable to average situations throughout the United States. When a cost estimate is prepared for broad applicability, however, it can only be regarded as being suitable for preliminary estimates of what might be considered average situations. The cost data and manpower requirements for estimating operating costs were based on the experience of the investigators, extensive data concerning design details, and actual construction costs during the period 1950 to 1968. This information was supplemented by field visits, and the examination of operating and maintenance records.

From the extensive data acquired by Black and Veatch, graphical cost relationships were developed. These are plotted in a log-log format in Reference 6. Much of the graphical information was later converted by Smith and Eilers (Reference 10 and 15) to exponential equations by linear and polynomial curve fitting. This is the form of the equations appearing in the CONCOS and TRTMNT subroutines.

It should be recognized that in the development of average cost data it is impractical to recognize all variations of design occurring among individual projects. Variations in cost from one specific project to another can be attributed to differences of design details, construction site conditions, and the economic climate at the time the bids are taken. Differences in costs will tend to be minimized if many different components and processes are involved in the construction project due to the tendency for composite estimates to vary less than the individual components. For this reason we would estimate that the variation in actual construction cost data compared to estimates provided by REMOVE will tend to be more pronounced in small projects involving relatively little additional equipment. In these cases, however, the cost of chemicals will usually be the dominant factor in phosphorus removal costs and the overall cost estimate should be a valid one.

Several processes included in the TRTMNT subroutine do not have cost equations in the program listing. They may easily be added as valid cost data becomes available. We were not able in the course of this contract to find information on these processes which would lend itself to curve fitting techniques. The affected processes include aerobic digestion, waste stabilization ponds, sodium hydroxide feeding and storage, and fluidized bed incineration. Except for aerobic digestion, which is being used more frequently now, the other processes will not appear frequently in treatment plant flow sheets.

Valid Ranges for Design Parameters Calculated by REMOVE

As discussed above, the mathematical cost relationships used in REMOVE have been developed from linear and polynomial curve fitting techniques. The cost calculations are valid only over the range of the regression data points used to generate the data points. Where the cost relationships are linear, some extrapolation above and below the data points may be reasonable. The range of validity of the cost calculations for the various processes is given in Table 10. Costs of some supplies, such as chemicals for phosphorus removal are directly input by the user if the assumed value is not correct for the particular area or region in question.

If the user selects design parameters which are outside the range shown in Table 10, the program will print a warning message. If the user is satisfied that a linear extrapolation is involved or that the input value is just barely out of the valid range, the program can be continued satisfactorily.

Assumptions Concerning Additional Capacity and Input Information

The model is based on the following assumptions concerning the addition of sludge handling equipment as a consequence of increased sludge production.

Table 10

CONSTRUCTION COST - VALID RANGES FOR SIZING PARAMETERS

Process Name	Independent Sizing Parameter	Units	Valid Range
Raw Waste Pumping	Initial Firm Capacity	MGD	.5-300
Pre Treatment	Maximum Capacity	MGD	1-200
Flocculation Basin Before Primary	Maximum Capacity	MGD	1-200
Primary Settler	Surface Area of Settler	Thos Sq Ft	1-30
Primary Sludge Pump	Initial Firm Capacity	GPM	30-5000
Trickling Filter	Media Volume	Thos Cu Ft	3-9000
Aeration Basin	Liquid Volume	Thos Cu Ft	3-4000
Diffused Air System	Initial Firm Blower Capacity	Thos CFM	.02-200
Mechanical Aeration	Total Installed Capacity	HP	20-5000
Secondary Settler	Surface Area of Settler	Thos Sq Ft	1-30
Recirculation Pumping (1)	Maximum Capacity	MGD	.5-300
Chlorination Feeding System	Average Chlorine Use	lbs/day	20-8000
Chlorination Contact Basin	Liquid Volume	Thos Cu Ft	3-300
Multi Media Filtration	Maximum Capacity	MGD	1-200
Recirculation Pumping (2)	Maximum Capacity	MGD	.5-300
Anaerobic Digester	Sludge Volume	Thos Cu Ft	30-6000
Sludge Drying Beds	Surface Area of Beds	Thos Sq Ft	7-4000
Vacuum Filter	Filter Area	Sq Ft	80-6000
Centrifuge	Firm Capacity	GPM	1.5-700
Multiple Hearth Incineration	Capacity	Lbs dry solids/hr	700-30,000
Recarbonation Basin (1)	Liquid Volume	Thos Cu Ft	1-400
Recarbonation Basin (2)	Liquid Volume	Thos Cu Ft	1-400
Tertiary Settler (1)	Surface Area of Settler	Thos Sq Ft	1-200
Tertiary Settler (2)	Surface Area of Settler	Thos Sq Ft	1-200
Gravity Thickener	Surface Area	Thos Sq Ft	.02-20
Recalcination	Maximum Capacity	MGD	1-200

1. Existing equipment will be operated up to the maximum nominal time before any new equipment is constructed. Nominal values selected for the various units have been selected from Reference 10.

2. When additional sludge handling units are constructed, the sizing will be performed as follows:

   a. The maximum size needed with phosphorus removal is determined. This will occur sometime within the chosen time horizon.

   b. The time when present capacity will be exceeded is determined.

   c. The maximum size needed during the chosen time horizon is constructed at the time when present capacity is first exceeded.

3. Existing equipment used for sludge handling is assumed to be in sufficiently good condition to be operated throughout the chosen time horizon. The user of the model may wish to shorten the time horizon if it is expected that major changes will be necessary to existing equipment.

4. Sludge handling schemes will generally be chosen to include the following processes:

   a. thickening

   b. digestion

   c. dewatering

   d. incineration

If there is no existing sludge thickening provided at a treatment plant, the model assumes that gravity thickening, as a minimum, will be required. If there are no provisions for sludge drying, the model assumes that vacuum filtrating will be required. Anaerobic digestion capacity will not be increased by the model as it is assumed that alternatives to this process are available which will result in lower cost. This may include dewatering and incineration of partially stabilized sludges. It is also expected that aerobic digestion will be used more frequently in the future. The model will calculate costs associated with landfill disposal of digested dewatered sludges in addition to incineration. We expect, however, that incineration may increase in popularity. The costs of land spreading digested sludges is not included in the model.

At the present time the model will include the cost of upgrading a primary treatment plant to secondary treatment as a cost associated with phosphorus removal. If this is not desired, the strategy can be run twice in the following manner.

The upgrading is performed on the present primary treatment plant and all costs of the particular strategy are calculated. Then using the secondary treatment sizing parameters selected by the model as input data to the model, the strategy is run again, this time assuming that the plant has secondary treatment. The cost of phosphorus removal without the cost of upgrading to secondary treatment is the result achieved in the second run.

As with the primary upgrading costs, the cost of adding chlorination to plants not having this equipment will also be charged to phosphorus removal. These decisions were made by the EPA program monitor early in the project. If the user does not wish to include these costs, the long printout may be requested and the unit cost of chlorination subtracted from the unit cost summary.

The model is presently restricted to the treatment and sludge handling schemes shown in Appendices A and B. The process schematics shown will be suited to most treatment plant configurations although occasionally variations such as a two-stage trickling filter may require modification of the model.

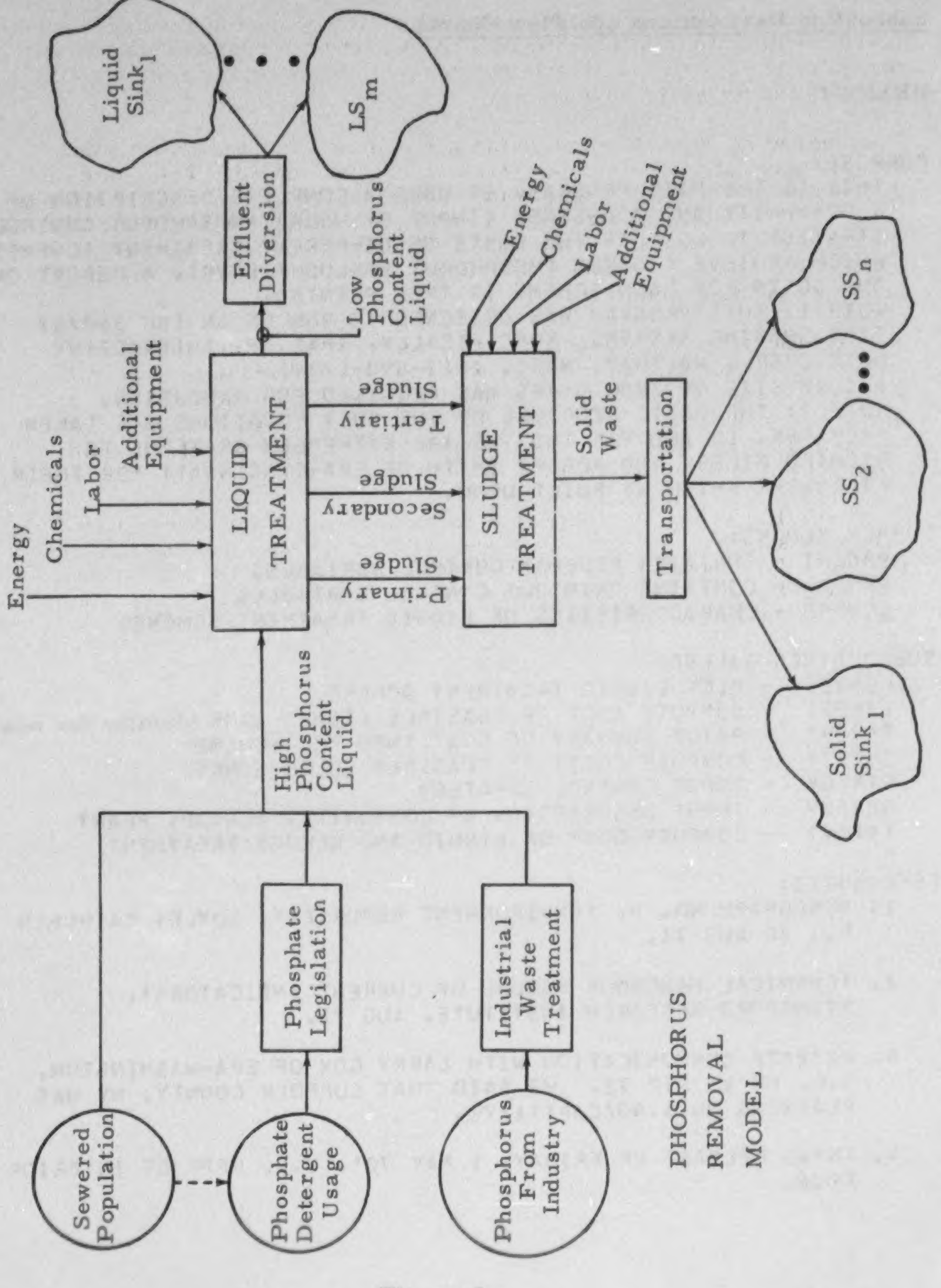

Sewered Population
Phosphate Detergent Usage
Phosphorus From Industry
Phosphate Legislation
Industrial Waste Treatment
PHOSPHORUS REMOVAL MODEL
High Phosphorus Content Liquid
Energy
Chemicals
Labor
Additional Equipment
LIQUID TREATMENT
Low Phosphorus Content Liquid
Effluent Diversion
Liquid Sink1
LSm
Primary Sludge
Secondary Sludge
Tertiary Sludge
Energy
Chemicals
Labor
Additional Equipment
SLUDGE TREATMENT
Solid Waste
Transportation
Solid Sink1
SS2
SSn

Figure 1
System Diagram

Subroutine Descriptions and Flow Charts

REMOVE

```
PURPOSE:
   THIS IS THE MAIN PROGRAM. IT USES A COMPLETE DESCRIPTION OF
   A COMMUNITY AND A DESIRED (INPUT BY USER) PHOSPHORUS CONTROL
   STRATEGY TO COMPUTE THE COSTS OF DIFFERENT TREATMENT SCHEMES
   WHICH ACHIEVE A GIVEN PHOSPHORUS EFFLUENT LEVEL. A REPORT ON
   THE COSTS FOR EACH SCHEME IS THEN PRINTED.
   NOTE 1: THIS PROGRAM WAS DESIGNED TO RUN ON AN IBM 360/67
   TIME SHARING SYSTEM.  SPECIFICALLY, THAT OF, INTERACTIVE
   DATA CORP., WALTHAM, MASS. (617-890-1234).
   A CORE SIZE OF 288K BYTES WAS REQUIRED FOR EXECUTION.
   NOTE 2: THE BASIC STUCTURE OF THE COST EQUATIONS WAS TAKEN
   FROM REF. 10 AND FOR THIS WE ARE EXTREMELY GRATEFUL TO
   RICHARD EILERS AND ROBERT SMITH OF EPA-CINCINNATI FOR THEIR
   FINE WORK WHICH WE BUILT UPON.

COMMON BLOCKS:
   PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
   PRNTR  - CONTAINS PRINTOUT CONTROL VARIABLES
   SCHEME - CHARACTERISTICS OF LIQUID TREATMENT SCHEMES

SUBROUTINES CALLED:
   LCHOSE  - PICK LIQUID TREATMENT SCHEME
   LSKCST  - COMPUTE COST OF FEASIBLE LIQUID SINK (dummy for now)
   REPORT  - PRINT SUMMARY OF COST INFO FOR SCHEME
   SSKCST  - COMPUTE COSTS OF FEASIBLE SOLID SINKS
   STRTGY  - INPUT CONTROL STRATEGY
   SYSTEM  - INPUT DESCRIPTION OF COMMUNITY, SEWAGE, PLANT
   TRTMNT  - COMPUTE COST OF LIQUID AND SLUDGE TREATMENT

REFERENCES:
   1. MONOGRAPH NO. 9, 'ENVIRONMENT REPORTER', DOYLE, KATHLEEN
      F., 20 AUG 71.

   2. 'CHEMICAL HANDBOOK MANUAL OF CURRENT INDICATORS',
      STANDFORD RESEARCH INSTITUTE, AUG 71.

   3. PRIVATE COMMUNICATION WITH LARRY COX OF EPA-WASHINGTON,
      D.C. ON 11 SEP 72.  HE SAID THAT SUFFOLK COUNTY, NY WAS
      PLANNING ON $.40/CAPITA/YR.

   4. 'NEWS RELEASE OF FRIDAY, 1 MAY 70', U.S. DEPT OF INTERIOR
      FWQA.
```

5. 'REPORT TO OECD WORK GROUP ON DETERGENTS', BUNCH, ROBERT L., SEP 71.

6. 'ESTIMATING COSTS AND MANPOWER REQUIREMENTS FOR CONVENTIONAL WASTEWATER TREATMENT FACILITIES', PATTERSON, W.L. AND BANKER, R.F. OF BLACK & VEATCH, CONSULTING ENGINEERS, EPA REPORT NO. 17090 DAN.

7. MYSELF

8. 'SEWAGE TREATMENT PALNT CONSTRUCTION COST INDEX', EPA-OFFICE OF WATER PROGRAMS.

9. 'WHOLESALE PRICES AND PRICE INDICES - INDUSTRIAL COMMODITIES', U.S. DEPT. OF LABOR.

10. 'COST2', A COMPUTER PROGRAM BY RICHARD EILERS OF EPA-CINCINNATI, OHIO. 'COST2' COMPUTERIZES THE GRAPHS OF REFERENCE 6.

11. PRIVATE COMMUNICATION WITH W.C. KRUMRI OF PROCTER & GAMBLE, CINCINNATI, OHIO (513-562-2859) ON 6 SEP 72. HE SAID THAT ANY NUMBER FROM -.05(FOR SODIUM CARBONATE) TO +.26(FOR CITRIC ACID) WAS VALID BECAUSE NO ONE SUBSTANCE HAS BEEN ACCEPTED AS A PHOSPHATE SUBSTITUTE.

12. 'PROCESS DESIGN MANUAL FOR PHOSPHORUS REMOVAL', BLACK & VEATCH, CONSULTING ENGINEERS, EPA REPORT NO. 17010-GNP.

13. 'COST AND PERFORMANCE ESTIMATES FOR TERTIARY WASTEWATER TREATING PROCESSES', SMITH, ROBERT AND MCMICHAEL, WALTER F., EPA-CINCINNATI, OHIO, JUN 69.

14. 'EMPLOYMENT & EARNINGS STATISTICS - WATER, STEAM, & SANITARY SYSTEMS (SIC 494-497)', U.S. DEPT. OF LABOR.

15. 'PRELIMINARY DESIGN AND SIMULATION OF CONVENTIONAL WASTEWATER RENOVATION SYSTEMS USING THE DIGITAL COMPUTER', ROBERT SMITH, EPA- CINCINNATI, MAR 68. THIS REPORT PROVIDES A THEORECTICAL BACKGROUND FOR REFERENCE 6.

```
NUMERIC CONSTANTS:
        .020825 = POUNDS/GAL FOR LIQUID POLYMER
        .029    = ASSUMED RATIO OF TRICKLING FILTER SLUDGE
                  WASTING STREAM VOLUME TO INPUT VOLUME
        .075    = POUNDS OF AIR/CUBIC FOOT
        .123    = POUNDS OF CO2/ CUBIC FOOT
        .125    = ENDOGENOUS RESPIRATION CONSTANT AT 20C
        .232    = POUNDS OF O2/ POUND OF AIR
        .4902   = POUNDS/GAL FOR LIQUID ALUM
        .6      = ASSUMED FRACTION OF MLVSS WHICH ARE ACTIVE
        .7      = ASSUMED RATIO OF MIXED LIQUOR VOLATILE
                  SUSPENDED SOLIDS TO MLSSAR
        .7457   = KILOWATTS/HORSEPOWER
       1.506    = WQO-STP INDEX FOR JAN 71 NATIONAL AVERAGE $
       2.27     = POUNDS OF FECL2/POUND OF FE
       2.6      = POUNDS/GAL FOR FECL2
       2.89     = POUND OF FECL3/ POUND OF FE
       3.95     = POUNDS/GAL FOR FECL3
       4.22     = POUNDS OF NAAL/POUND OF AL
       5.4      = POUNDS/GAL FOR ALUM
       5.4      = (ASSUMED) POUNDS/GAL FOR NAAL
       6.       = ASSUMED DEPTH OF TRICKLING FILTER MEDIA
       7.48     = GALLONS/CUBIC FOOT FOR WATER
       8.33     = POUNDS/GAL FOR WATER
      11.       = POUNDS OF ALUM/POUND OF AL
      24.       = HOURS/DAY
      30.       = DAYS/MONTH
      60.       = MINUTES/HOUR
     180.       = ASSUMED CONCENTRATION OF SUSPENDED SOLIDS IN
                  TRICKLING FILTER SLUDGE WASTING STREAM
     365.       = DAYS/YEAR
    1440.       = MINUTES/DAY
    2000.       = POUNDS/TON
   43560.       = SQUARE FEET/ACRE

AUTHOR:
   DAVID A BARNES   19DEC72
   RONALD ORNER
   JBF SCIENTIFIC CORP.
   2 RAY AVENUE
   BURLINGTON, MA  01803
   (617-273-0270)
```

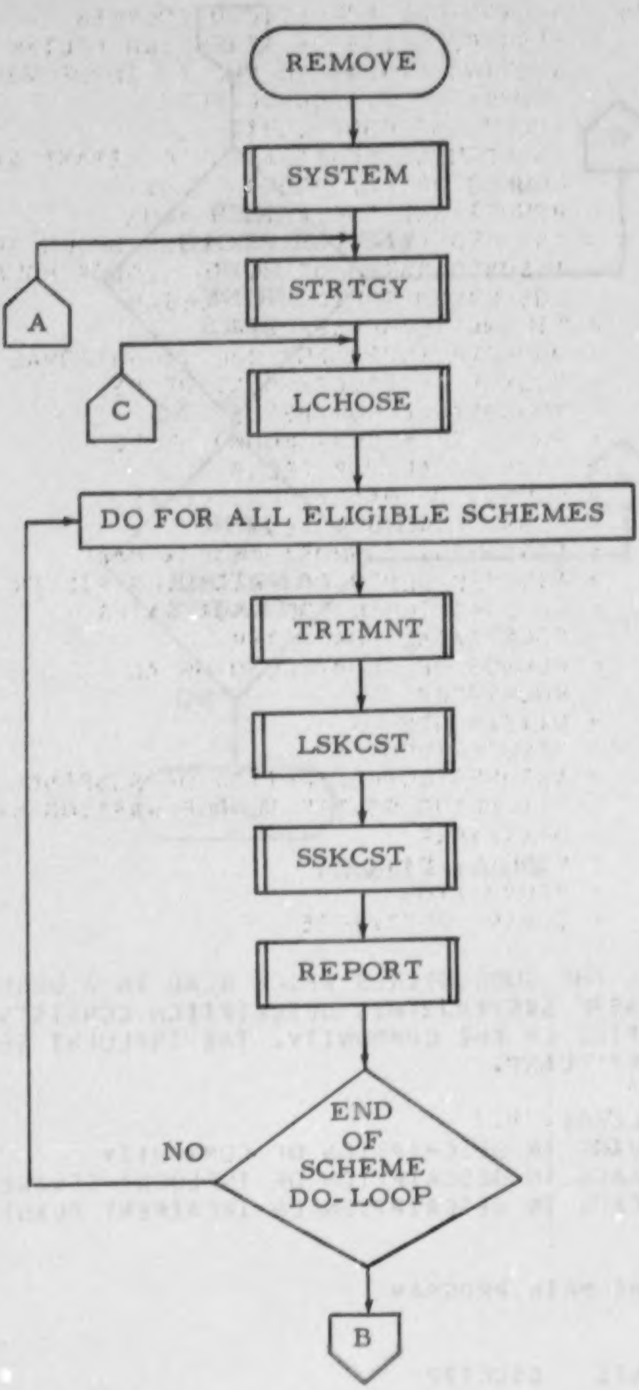

REMOVE
SYSTEM
STRTGY
A
LCHOSE
C
DO FOR ALL ELIGIBLE SCHEMES
TRTMNT
LSKCST
SSKCST
REPORT
END OF SCHEME DO-LOOP
NO
B

Figure 2

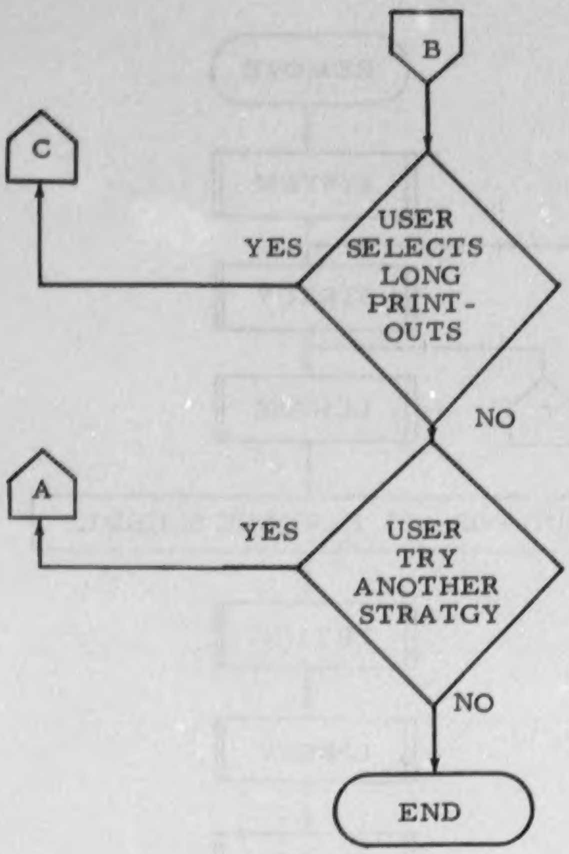

B
C
USER SELECTS LONG PRINT-OUTS
YES
NO
A
USER TRY ANOTHER STRATGY
YES
NO
END

Figure 2 (cont.)

SYSTEM

```
PURPOSE:
   SYSTEM CALLS THE SUBROUTINES WHICH READ IN A DESCRIPTION OF
   THE TOTAL WASTE SYSTEM. THIS DESCRIPTION CONSISTS OF THE
   CHARACTERISTICS OF THE COMMUNITY, THE INFLUENT SEWAGE, AND
   THE TREATMENT PLANT.

SUBROUTINES CALLED:
   CMMNTY  - READS IN DESCRIPTION OF COMMUNITY
   SEWAGE  - READS IN DESCRIPTION OF INFLUENT SEWAGE
   PLANT   - READS IN DESCRIPTION OF TREATMENT PLANT

CALLED BY:
   REMOVE  - THE MAIN PROGRAM

AUTHOR:
   DAVID A BARNES    05OCT72
```

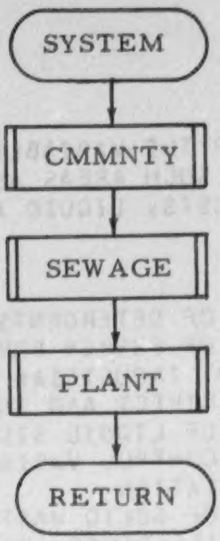
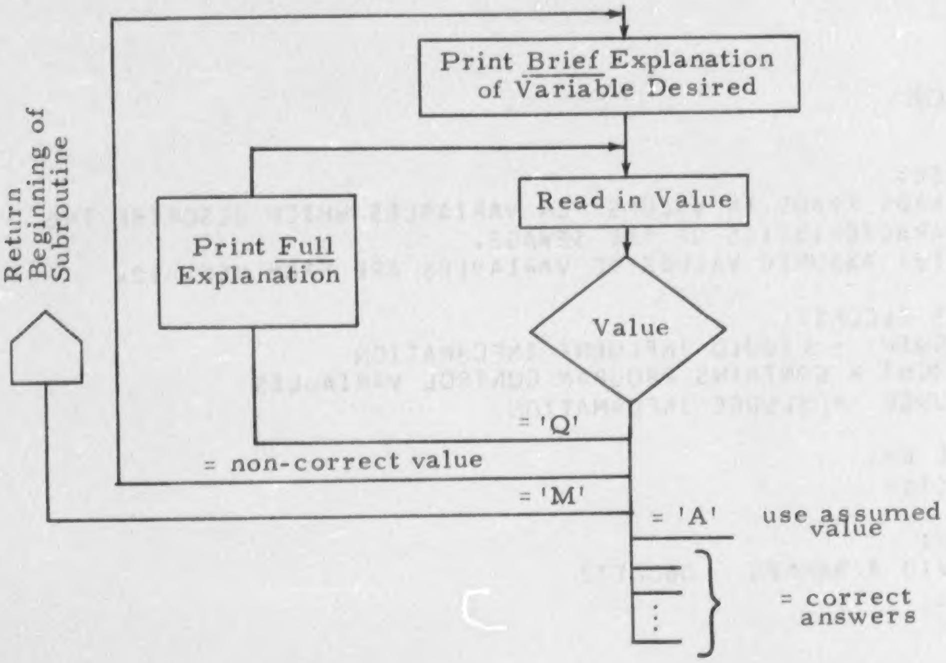

SYSTEM
CMMNTY
SEWAGE
PLANT
RETURN

Figure 3

SYSTEM and its three (3) subroutines CMMNTY, SEWAGE, and PLANT have the function of reading in and storing large amounts of information into selected common blocks whose variables describe the community and its treatment plant.

Each variable is filled in the following manner:


Print Brief Explanation of Variable Desired
Read in Value
Print Full Explanation
Value
= 'Q'
= non-correct value
= 'M'
= 'A'
use assumed value
= correct answers
Return Beginning of Subroutine

CMMNTY

```
PURPOSE:
   CMMNTY READS IN VALUES FOR THE VARIABLES WHICH DESCRIBE THE
   COMMUNITY.  THESE INCLUDE SUCH AREAS AS: SEWERED POPULATION,
   ENERGY-, TRANSPORTATION-COSTS, LIQUID AND SOLID
   SINKS.

COMMON BLOCKS:
   DTRGNT  - CHARACTERISTICS OF DETERGENTS AND USAGE
   ENGCST  - DELIVERED COSTS OF ENERGY FORMS
   INDSTY  - INFORMATION ABOUT INDUSTRIAL PHOSPHORUS EFFLUENTS
   LBRCST  - COSTS OF LABOR (DIRECT AND INDIRECT)
   LSINK   - CHARACTERISTICS OF LIQUID SINKS
   PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
   SEWPOP  - THE SEWERED POPULATION
   SSINK   - CHARACTERISTICS OF SOLID WASTE SINKS
   TSCST   - TIME AND SPACE DIFFERENCE COSTS

CALLED BY:
   SYSTEM

AUTHOR:
   DAVID A BARNES   19DEC72
```

SEWAGE

```
PURPOSE:
   SEWAGE READS IN VALUES FOR VARIABLES WHICH DESCRIBE THE
   CHARACTERISTICS OF THE SEWAGE.
   NOTE: ASSUMED VALUES OF VARIABLES ARE FROM REF. 10.

COMMON BLOCKS:
   LIQUID  - LIQUID INFLUENT INFORMATION
   PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
   SLUDGE  - SLUDGE INFORMATION

CALLED BY:
   SYSTEM

AUTHOR:
   DAVID A BARNES   06OCT72
```

PLANT

PURPOSE:
PLANT READS IN VALUES OF VARIABLES WHICH DESCRIBE THE SEWAGE TREATMENT PLANT.
NOTE: THE ASSUMED VALUES FOR 'APVAR', 'MINRV', AND 'MAXRV' ARE FROM REF. 10.

COMMON BLOCKS:
CHMCST - CONTAINS DELIVERED COSTS OF CHEMICALS
PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
TPLANT - DESCRIPTION OF TREATMENT PLANT

CALLED BY:
SYSTEM

AUTHOR:
DAVID A BARNES 06OCT72

STRTGY

PURPOSE:
STRTGY CALLS THE SUBROUTINES WHICH READ IN VALUES FOR THE VARIABLES OF THE DESIRED CONTROL STRATEGY.
THESE VARIABLES ARE IN THE CATEGORIES OF: TIME, EFFLUENT LIMITS, DETERGENT RESTRICTIONS, AND INDUSTRIAL CONTROLS.

SUBROUTINES CALLED:
DTGLIM - READS IN RESTRICTIONS ON DETERGENT PHOSPHATES
EFFLIM - READS IN RESTRICTIONS ON TREATMENT PLANT EFFLUENT
INDLIM - READS IN RESTRICTIONS ON INDUSTRIAL EFFLUENTS (DUMMY FOR NOW)
INTIME - READS IN DESCRIPTION OF TIME HORIZON

CALLED BY:
REMOVE - THE MAIN PROGRAM

AUTHOR:
DAVID A BARNES 06OCT72

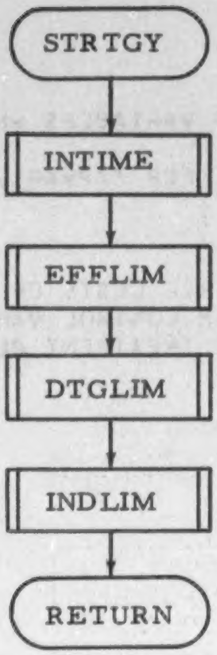


Figure 4

INTIME

```
PURPOSE:
   INTIME READS IN A DESCRIPTION OF THE TIME HORIZON DESIRED.
   IT THEN CALLS SPFNC TO COMPUTE THE SEWERED POPULATION FOR
   EACH TIME PERIOD.

COMMON BLOCKS:
   PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
   TIME     - PARAMETERS OF TIME HORIZON

SUBROUTINES CALLED:
   SPFNC  - COMPUTES SEWERED POPULATION FOR ALL TIME PERIODS

CALLED BY:
   STRTGY  - CONTROL STRATEGY CALLING ROUTINE

AUTHOR:
   DAVID A BARNES    06OCT72
```

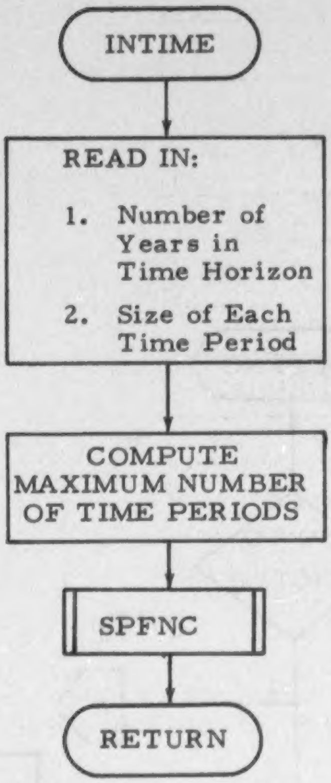

INTIME
READ IN:
1. Number of Years in Time Horizon
2. Size of Each Time Period
COMPUTE MAXIMUM NUMBER OF TIME PERIODS
SPFNC
RETURN

Figure 5

SPFNC

```
PURPOSE:
     SPFNC COMPUTES THE SIZE OF THE SEWERED POPULATION OVER ALL
   TIME PERIODS OF A GIVEN CONTROL STRATEGY.

COMMON BLOCKS:
   SEWPOP  - THE SEWERED POPULATION
   TIME    - PARAMETERS OF TIME HORIZON

CALLED BY:
   INTIME  - READS IN TIME HORIZON OF CONTROL STRATEGY

AUTHOR:
   DAVID A BARNES   06OCT72
```

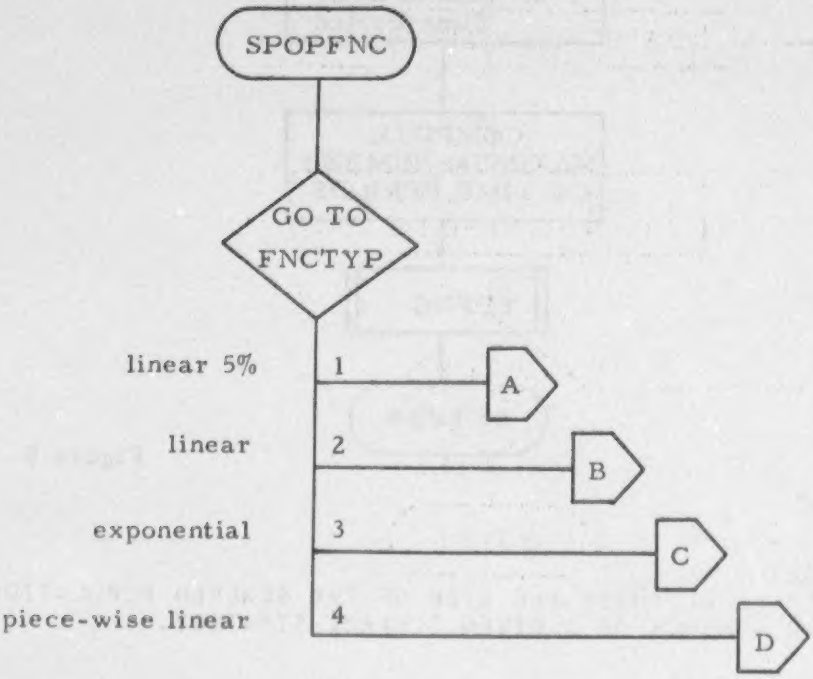

SPOPFNC
GO TO FNCTYP
linear 5%
1
A
linear
2
B
exponential
3
C
piece-wise linear
4
D

Figure 6

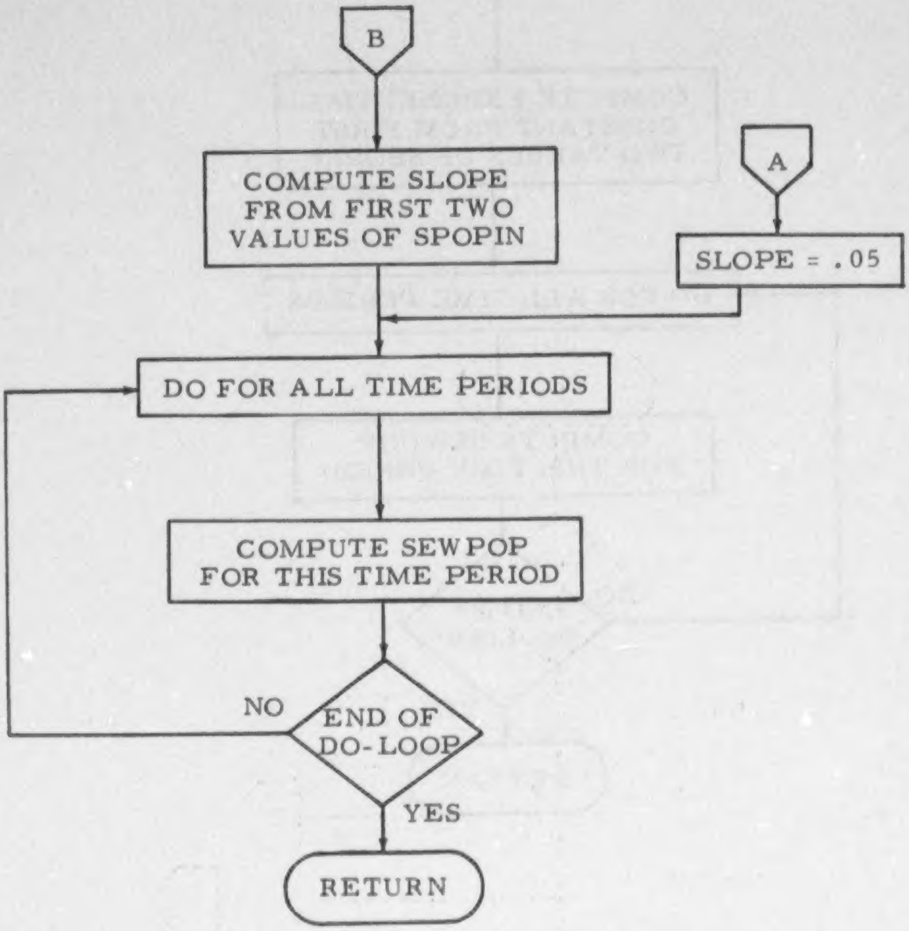

B
A
COMPUTE SLOPE FROM FIRST TWO VALUES OF SPOPIN
SLOPE = .05
DO FOR ALL TIME PERIODS
COMPUTE SEWPOP FOR THIS TIME PERIOD
NO
END OF DO-LOOP
YES
RETURN

Figure 6 (cont.)

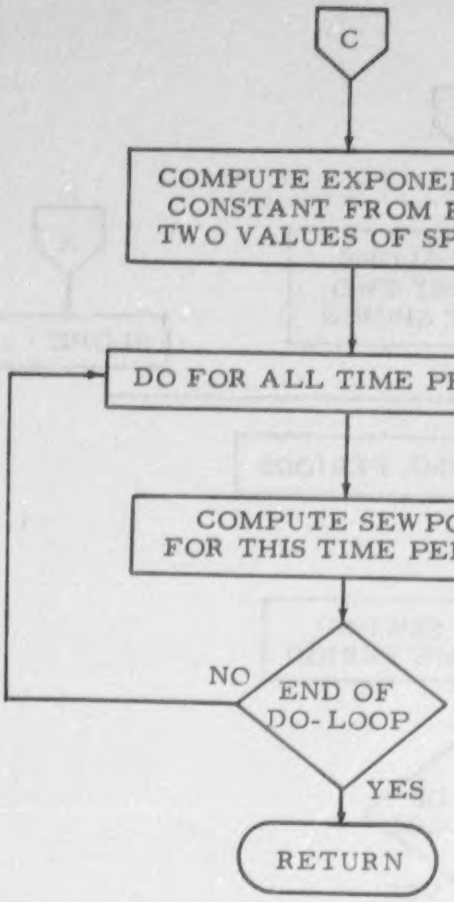

C
COMPUTE EXPONENTIAL CONSTANT FROM FIRST TWO VALUES OF SPOPIN
DO FOR ALL TIME PERIODS
COMPUTE SEWPOP FOR THIS TIME PERIOD
NO
END OF DO-LOOP
YES
RETURN

Figure 6 (cont.)

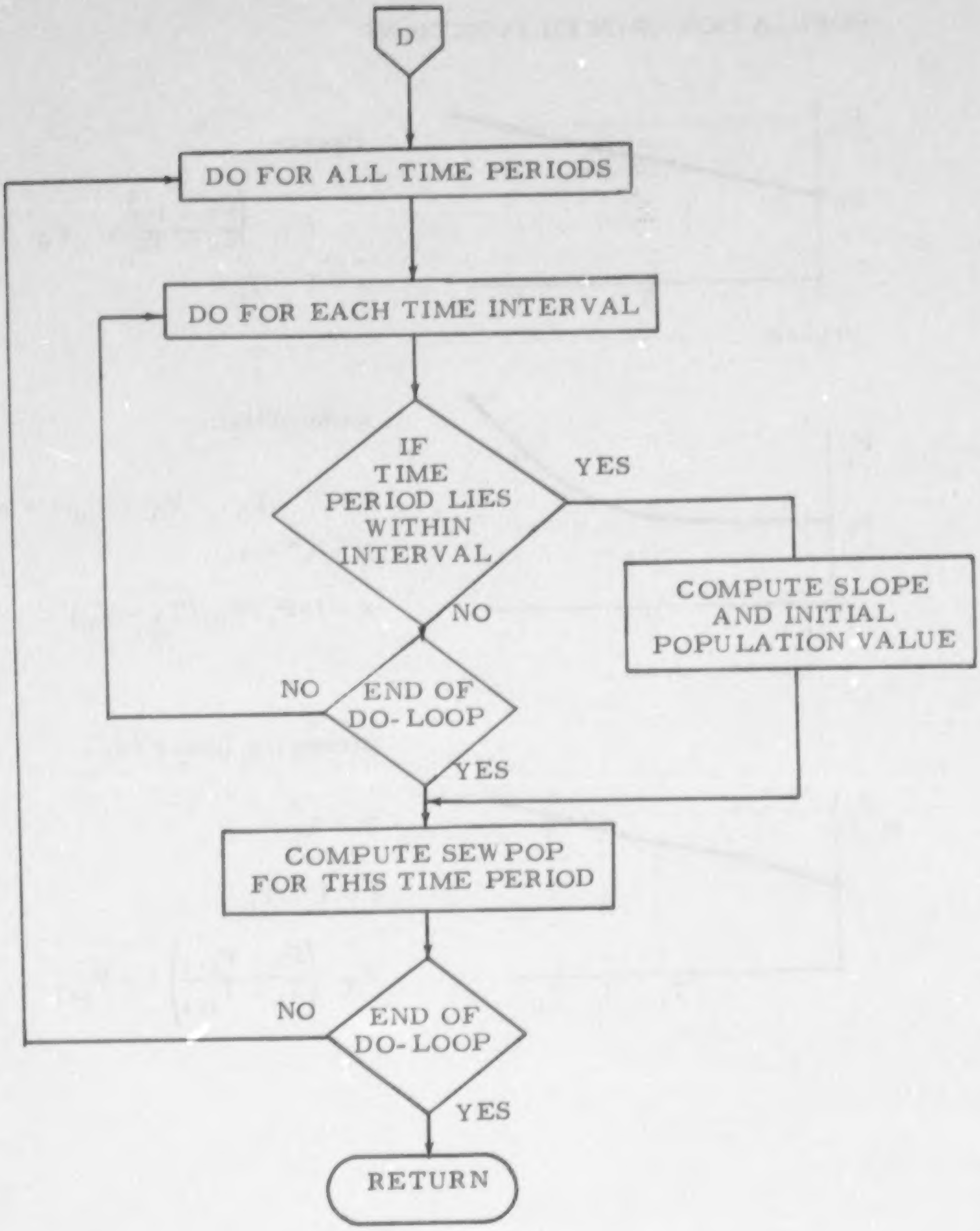
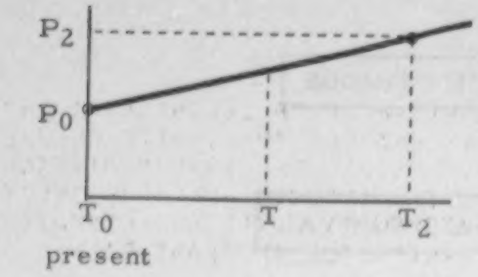

D
DO FOR ALL TIME PERIODS
DO FOR EACH TIME INTERVAL
IF TIME PERIOD LIES WITHIN INTERVAL
YES
NO
COMPUTE SLOPE AND INITIAL POPULATION VALUE
NO
END OF DO-LOOP
YES
COMPUTE SEWPOP FOR THIS TIME PERIOD
NO
END OF DO-LOOP
YES
RETURN

Figure 6 (cont.)

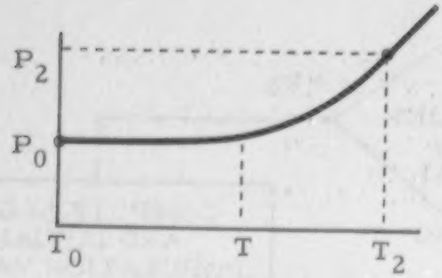
POPULATION GROWTH FUNCTIONS



linear:

$$P_T = \left(\frac{P_2 - P_0}{T_2 - T_0}\right) t + P_0$$

$t = T - T_0$



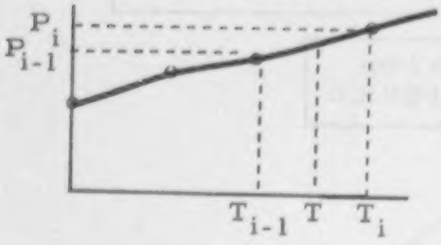
exponential:

$t = T - T_0$ $\quad P_T = P_0(1 + K)^t$

$K = e^x - 1$

$x = \ln P_2/P_0/(T_2 - T_0)$

piecewise linear fit:



$T < T_i$

$t = T - T_{i-1}$

$$P_T = \left(\frac{P_i - P_{i-1}}{T_i - T_{i-1}}\right) t + P_{i-1}$$

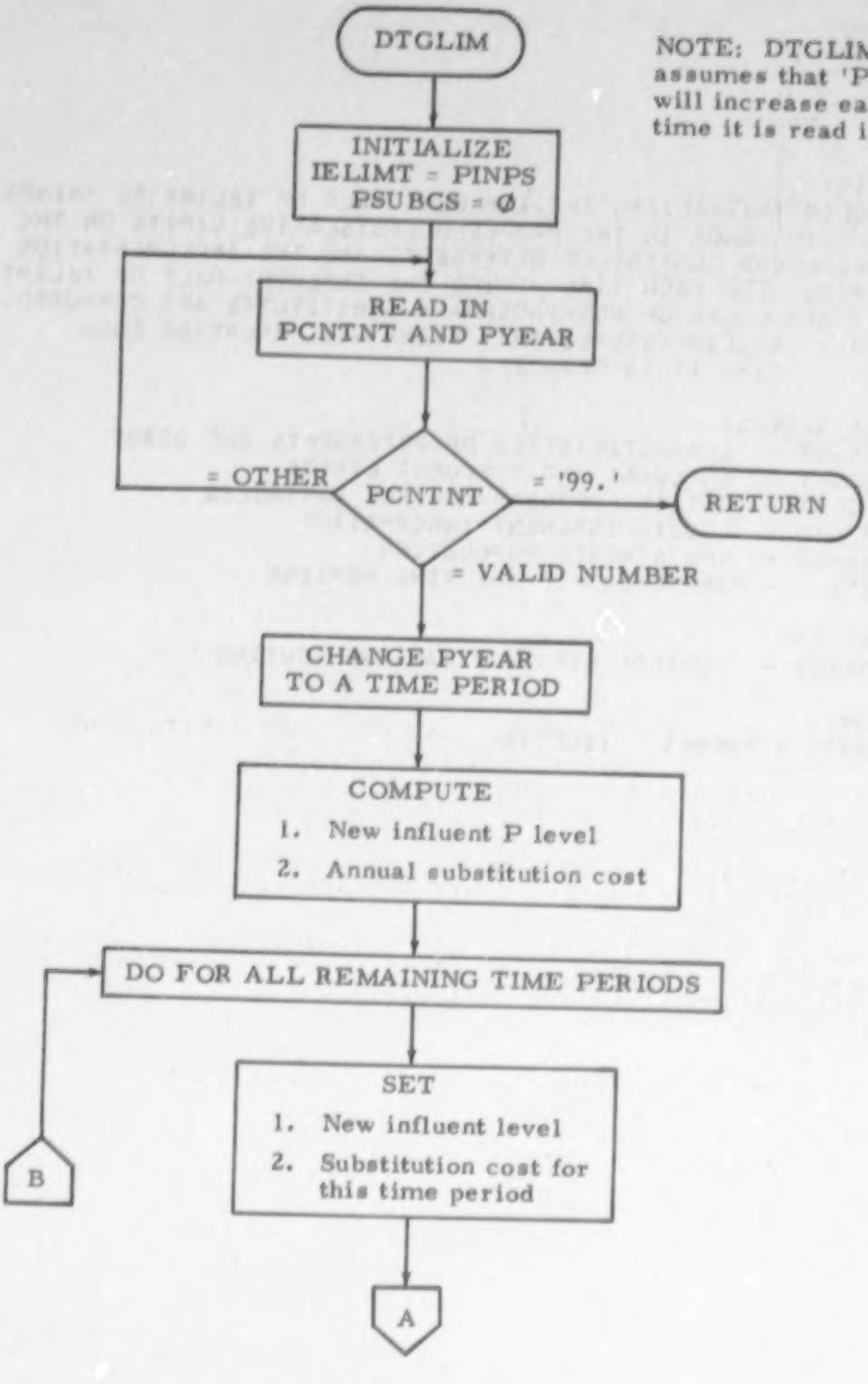
DTGLIM

```
PURPOSE:
   DTGLIM INITIALIZES THE INFLUENT-HALF OF IELIMT TO 'PINPS'
   DTRGLIM READS IN THE PROPOSED LEGISLATIVE LIMITS ON THE
   PHOSPHORUS CONTENT OF DETERGENTS AND THE IMPLEMENTATION
   TIMES.  FOR EACH TIME PERIOD THE INFLUENT-HALF OF IELIMT
   AND THE COSTS OF NON-PHOSPHATE SUBSTITUTES ARE COMPUTED.
   NOTE:  DTGLIM ASSUMES THAT PYEAR WILL INCREASE EACH
          TIME IT IS READ IN.

COMMON BLOCKS:
    DTRGNT -  CHARACTERISTICS OF DETERGENTS AND USAGE
    IELIMT -  INFLUENT AND EFFLUENT LIMITS
    PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
    LIQUID -  LIQUID INFLUENT INFORMATION
    SEWPOP -  THE SEWERED POPULATION
    TIME   - PARAMETERS OF THE TIME HORIZON

CALLED BY:
    STRTGY -  CONTROL STRATEGY CALLING ROUTINE

AUTHOR:
    DAVID A BARNES   11OCT72
```


DTGLIM
INITIALIZE
IELIMT = PINPS
PSUBCS = 0
READ IN
PCNTNT AND PYEAR
= OTHER
PCNTNT
= '99.'
RETURN
= VALID NUMBER
CHANGE PYEAR
TO A TIME PERIOD
COMPUTE
1. New influent P level
2. Annual substitution cost
DO FOR ALL REMAINING TIME PERIODS
SET
1. New influent level
2. Substitution cost for this time period
B
A

NOTE: DTGLIM assumes that 'PYEAR' will increase each time it is read in

Figure 7

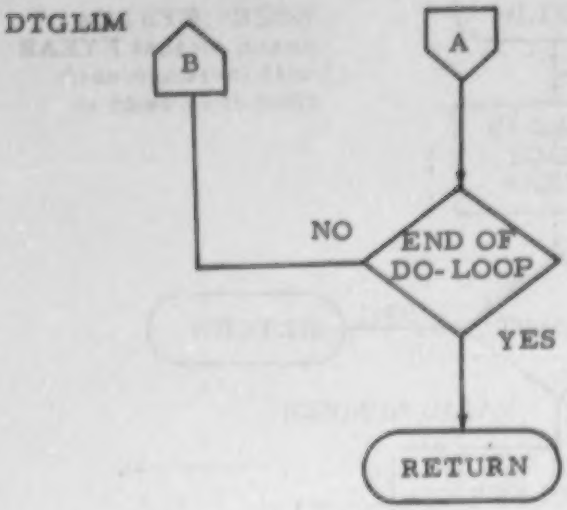


Figure 7 (cont.)

EFFLIM

```
PURPOSE:
   EFFLIM READS IN THE PHOSPHORUS EFFLUENT LIMITS AND
   CONSTRUCTS THE EFFLUENT-HALF OF IELIMT
   NOTE: EFFLIM ASSUMES THAT 'EYEAR' WILL INCREASE
   EACH TIME IT IS READ IN.

COMMON BLOCKS:
   IELIMT - LIMITS ON INFLUENT/EFFLUENT PHOSPHORUS
             CONCENTRATIONS
   PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
   SEWPOP - THE SEWERED POPULATION
   TIME   - INFO ABOUT THE TIME HORIZON

CALLED BY:
   STRTGY - THE CONTROL STRATEGY CALLING ROUTINE

AUTHOR:
   DAVID A BARNES   11OCT72
```

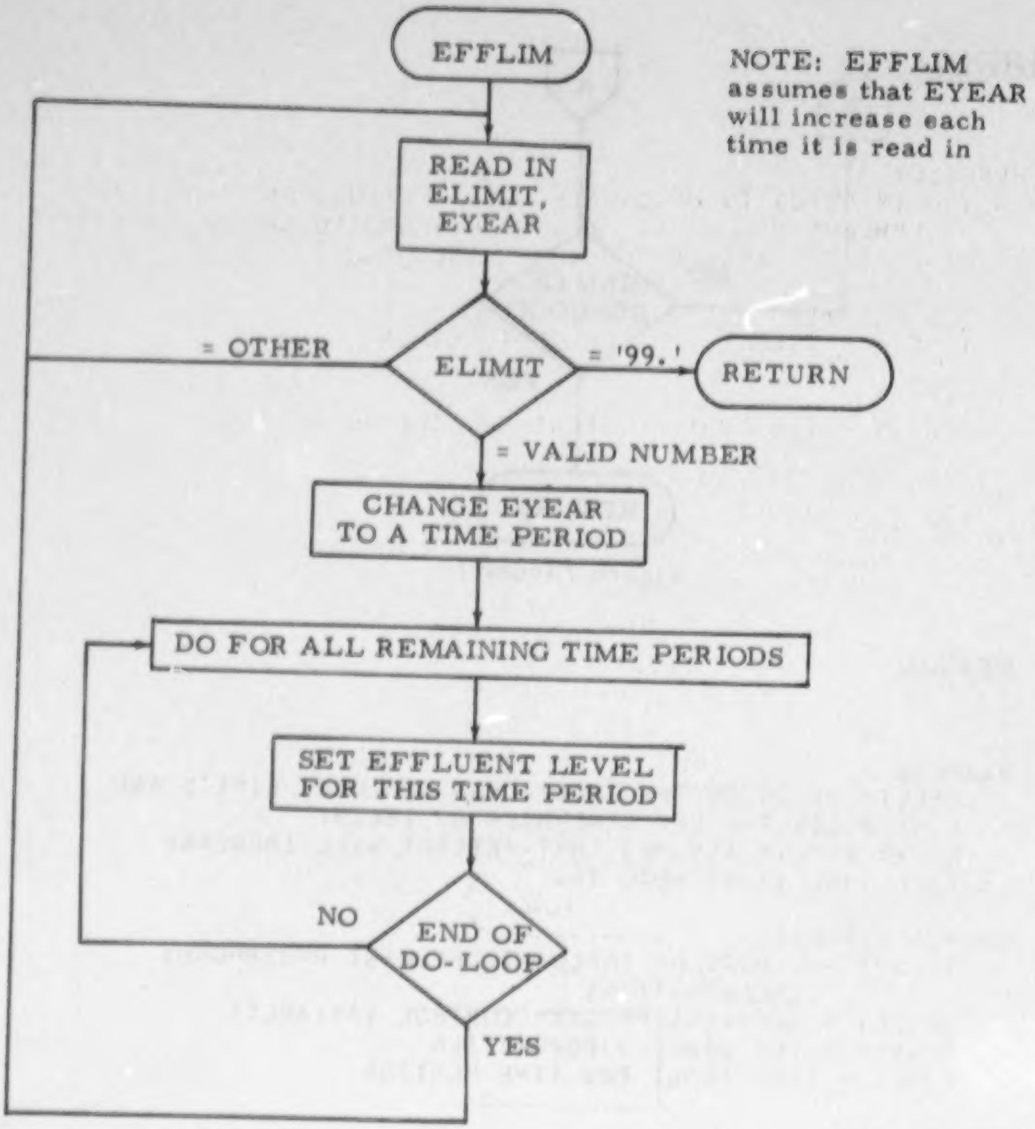

EFFLIM
NOTE: EFFLIM assumes that EYEAR will increase each time it is read in
READ IN ELIMIT, EYEAR
= OTHER
ELIMIT
= '99.'
RETURN
= VALID NUMBER
CHANGE EYEAR TO A TIME PERIOD
DO FOR ALL REMAINING TIME PERIODS
SET EFFLUENT LEVEL FOR THIS TIME PERIOD
NO
END OF DO-LOOP
YES

Figure 8

INDLIM

```
PURPOSE:
   INDLIM READS IN LEGISLATED RESTRICTIONS ON INDUSTRIAL
   PHOSPHORUS EFFLUENT.  THE CORRESPONDING CHANGES ARE THEN
   MADE TO THE INFLUENT-HALF OF IFLIMT.

COMMON BLOCKS:
   INDSTY - INDUSTRIAL EFFLUENT LEVELS

CALLED BY:
   STRTGY - THE CONTROL STRATEGY CALLING ROUTINE

AUTHOR:
   DAVID A BARNES   11OCT72
```

INDLIM
DUMMY FOR NOW
RETURN

Figure 9

LCHOSE

```
PURPOSE:
   LCHOSE MARKS AS ELIGIBLE FOR CONSIDERATION THOSE LIQUID
   TREATMENT SCHEMES WHICH WILL:
   1. ACHIEVE THE DESIRED MINIMUM EFFLUENT PHOSPHORUS LEVEL
   2. ACHIEVE A LEVEL CLOSE TO THAT DESIRED.

COMMON BLOCKS:
   IELIMT - LIMITS ON INFLUENT/EFFLUENT PHOSPHORUS
   PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
   LIQUID - LIQUID INFLUENT INFO
   SCHEME - INFO ABOUT LIQUID TREATMENT SCHEMES
   TIME   - INFO ABOUT TIME HORIZON
   TPLANT - INFO ABOUT TREATMENT PLANT PROCESSES

CALLED BY:
   REMOVE - THE MAIN PROGRAM

AUTHOR:
   DAVID A BARNES    12OCT72
```

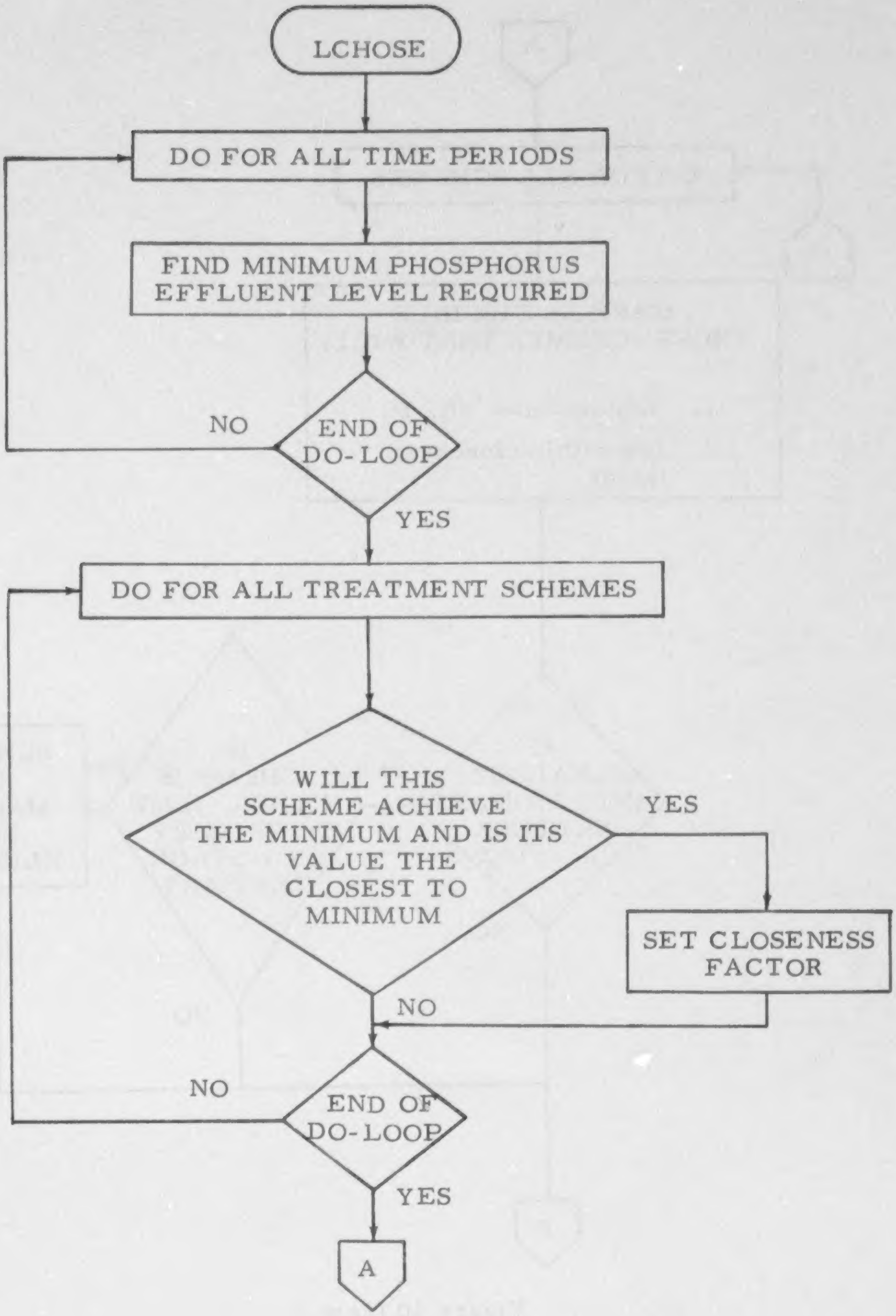

LCHOSE
DO FOR ALL TIME PERIODS
FIND MINIMUM PHOSPHORUS EFFLUENT LEVEL REQUIRED
END OF DO-LOOP
NO
YES
DO FOR ALL TREATMENT SCHEMES
WILL THIS SCHEME ACHIEVE THE MINIMUM AND IS ITS VALUE THE CLOSEST TO MINIMUM
YES
SET CLOSENESS FACTOR
NO
END OF DO-LOOP
NO
YES
A

Figure 10

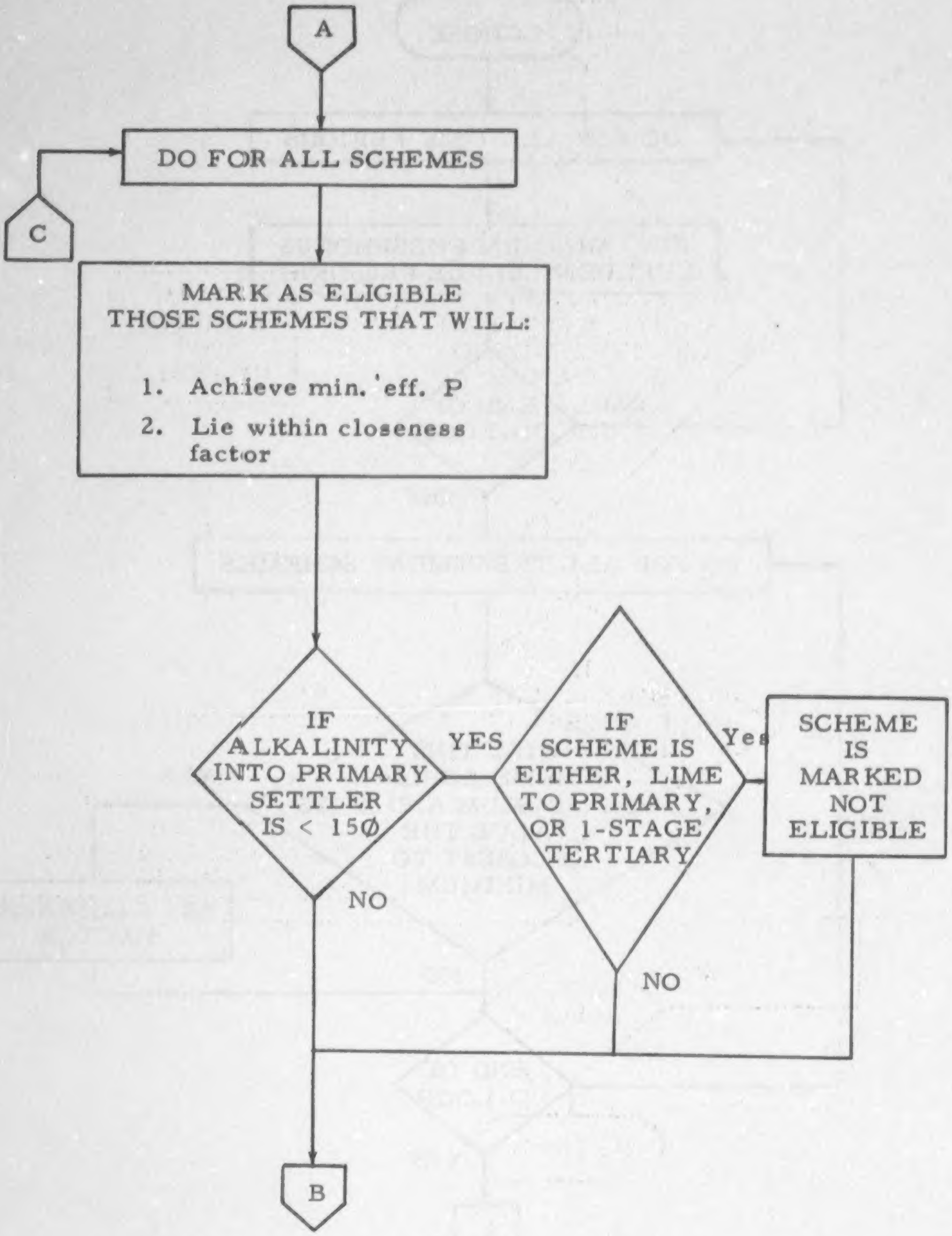

A
DO FOR ALL SCHEMES
C
MARK AS ELIGIBLE THOSE SCHEMES THAT WILL:
1. Achieve min. eff. P
2. Lie within closeness factor
IF ALKALINITY INTO PRIMARY SETTLER IS < 150
YES
NO
IF SCHEME IS EITHER, LIME TO PRIMARY, OR 1-STAGE TERTIARY
Yes
NO
SCHEME IS MARKED NOT ELIGIBLE
B

Figure 10 (cont.)

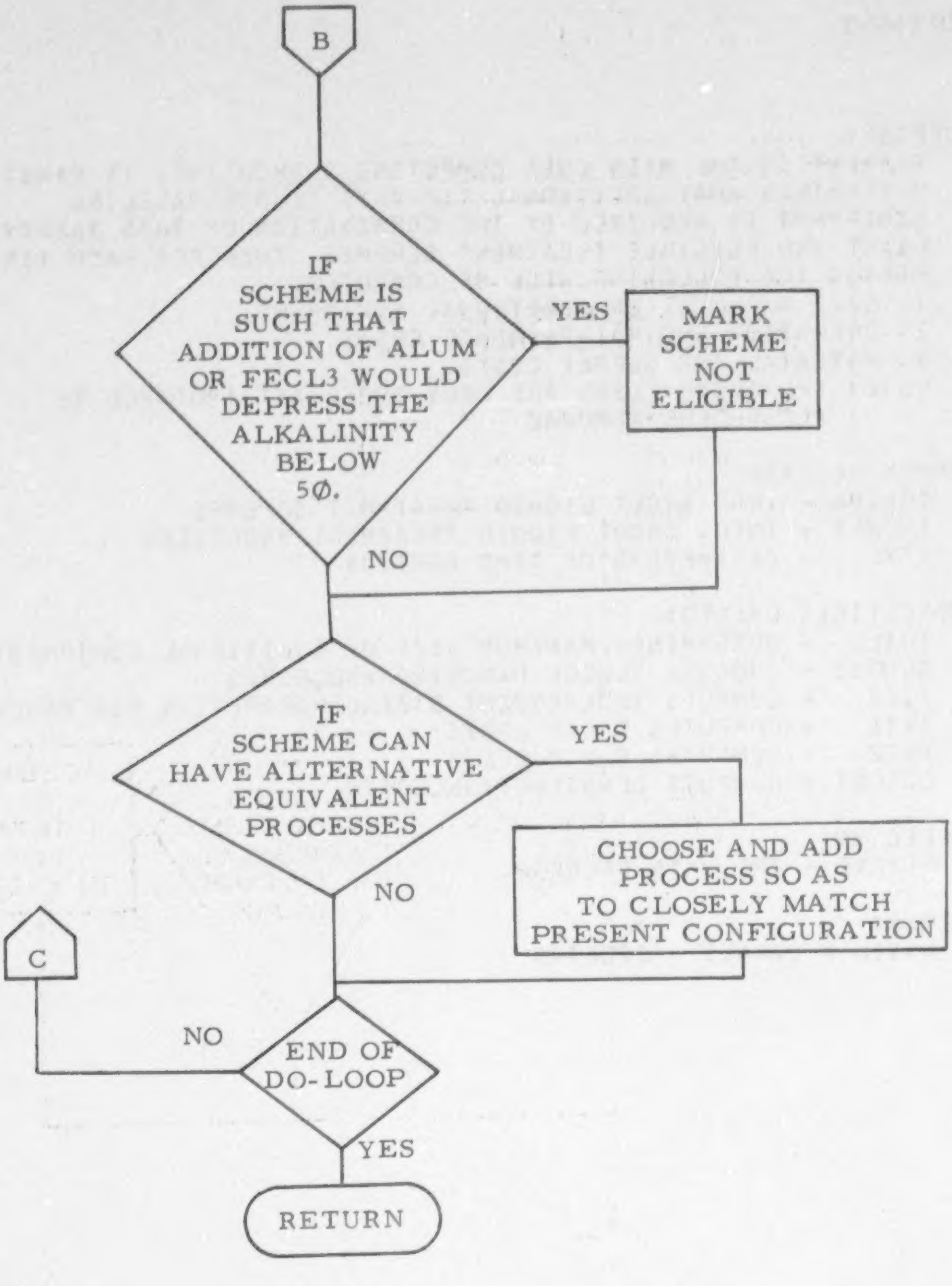

B
IF SCHEME IS SUCH THAT ADDITION OF ALUM OR FECL3 WOULD DEPRESS THE ALKALINITY BELOW 50.
YES
MARK SCHEME NOT ELIGIBLE
NO
IF SCHEME CAN HAVE ALTERNATIVE EQUIVALENT PROCESSES
YES
CHOOSE AND ADD PROCESS SO AS TO CLOSELY MATCH PRESENT CONFIGURATION
NO
C
NO
END OF DO-LOOP
YES
RETURN

Figure 10 (cont.)

TRTMNT

```
PURPOSE:
   TRTMENT IS THE MAIN COST COMPUTING SUBROUTINE. IT FIRST
   DETERMINES WHAT ADDITIONAL (IF ANY) SLUDGE HANDLING
   EQUIPMENT IS REQUIRED BY THE COMBINATION OF THIS TREATMENT
   PLANT AND ELIGIBLE TREATMENT SCHEME.  THEN FOR EACH TIME
   PERIOD THE FOLLOWING WILL BE COMPUTED.
   1. SIZE AND COST OF ADDITIONAL EQUIPMENT
   2. OPERATION AND MAINTAINENCE COSTS
   3. MATERIAL AND SUPPLY COSTS.
   NOTE: THE ABOVE COSTS ARE ONLY THOSE ATTRIBUTABLE TO
         PHOSPHORUS REMOVAL

COMMON BLOCKS:
   SCHEME - INFO ABOUT LIQUID TREATMNET SCHEMES
   TPLANT - INFO. ABOUT LIQUID TREATMENT PROCESSES
   TIME   - PARAMETERS OF TIME HORIZON

SUBROUTINES CALLED:
   BUILD  - DETERMINES MAXIMUM SIZE OF ADDITIONAL EQUIPMENT
   SCHOSE - CHOOSES SLUDGE HANDLING PROCESSES
   SIZE   - COMPUTE INDEPENDENT SIZING PARAMETERS FOR PROCESSES
   TRT1   - COMPUTES O & M COSTS
   TRT2   - COMPUTES O & M COSTS
   CCNCST - COMPUTS CONSTRUCTION COSTS

CALLED BY:
   REMOVE - THE MAIN PROGRAM

AUTHOR:
   DAVID A BARNES   12OCT72
```

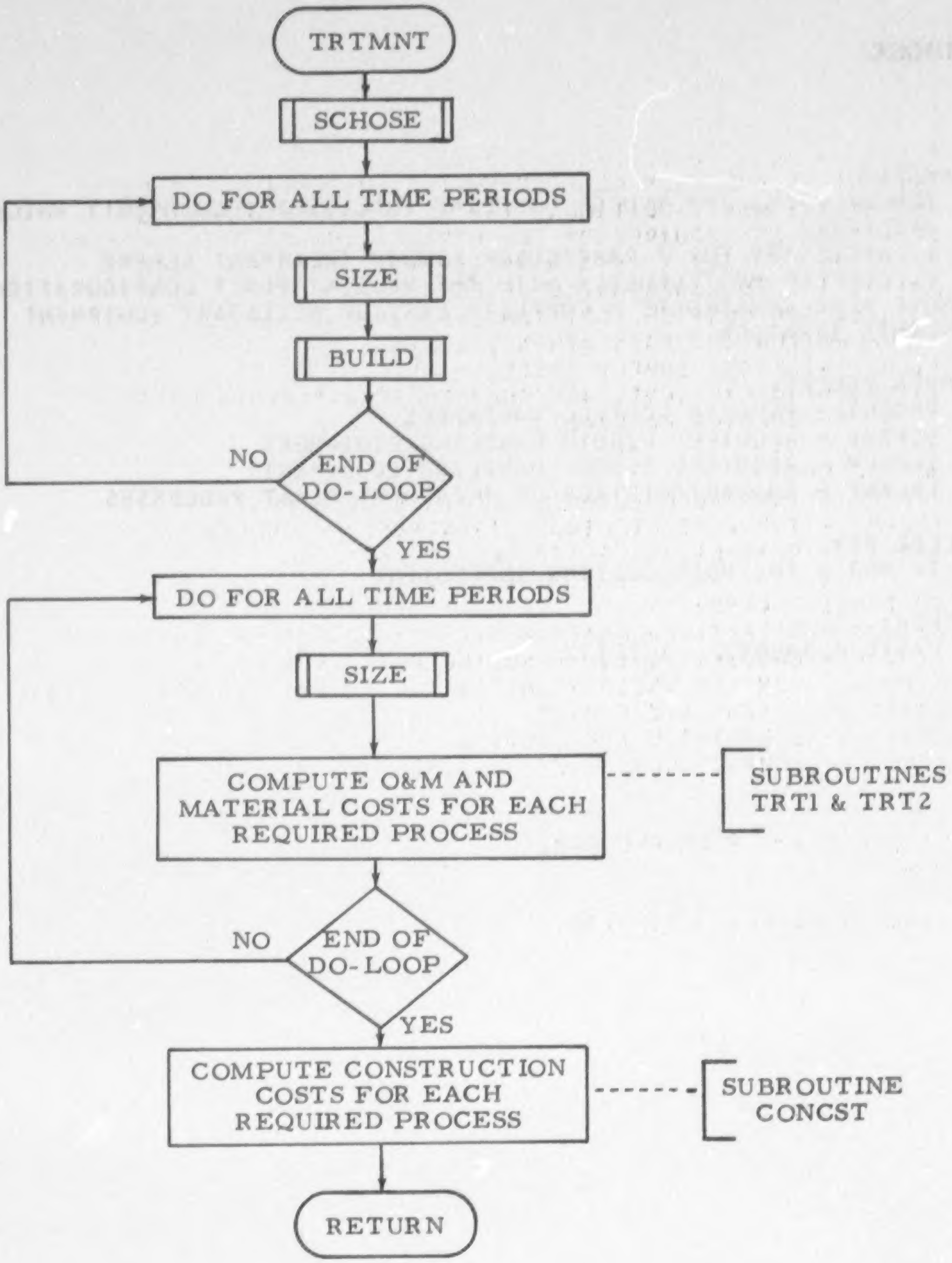

TRTMNT
SCHOSE
DO FOR ALL TIME PERIODS
SIZE
BUILD
NO
END OF DO-LOOP
YES
DO FOR ALL TIME PERIODS
SIZE
COMPUTE O&M AND MATERIAL COSTS FOR EACH REQUIRED PROCESS
SUBROUTINES TRT1 & TRT2
NO
END OF DO-LOOP
YES
COMPUTE CONSTRUCTION COSTS FOR EACH REQUIRED PROCESS
SUBROUTINE CONCST
RETURN

Figure 11

SCHOSE

```
PURPOSE:
   SCHOSE PICKS THE SLUDGE HANDLING PROCESSES (EQUIPMENT) WHICH
   ARE BOTH:
   1. NECESSARY FOR A PARTICULAR LIQUID TREATMENT SCHEME
   2. CONFORM MOST CLOSELY WITH THE PRESENT PLANT CONFIGURATION
SCHOSE ALSO CONSTRUCTS A COMPLETE LIST OF NECESSARY EQUIPMENT
FOR THIS STRATEGY

COMMON BLOCKS:
   PRGCNT - PROGRAM CONTROL VARIABLES
   SCHEME - REQUIRED LIQUID HANDLING EQUIPMENT
   SLGSCM - REQUIRED SLUDGE HANDLING EQUIPMENT
   TPLANT - CHARACTERISTICS OF TREATMENT PLANT PROCESSES

CALLED BY:
   TRTMNT - THE MAIN COSTING SUBROUTINE

AUTHOR:
   DAVID A BARNES    12OCT72
```

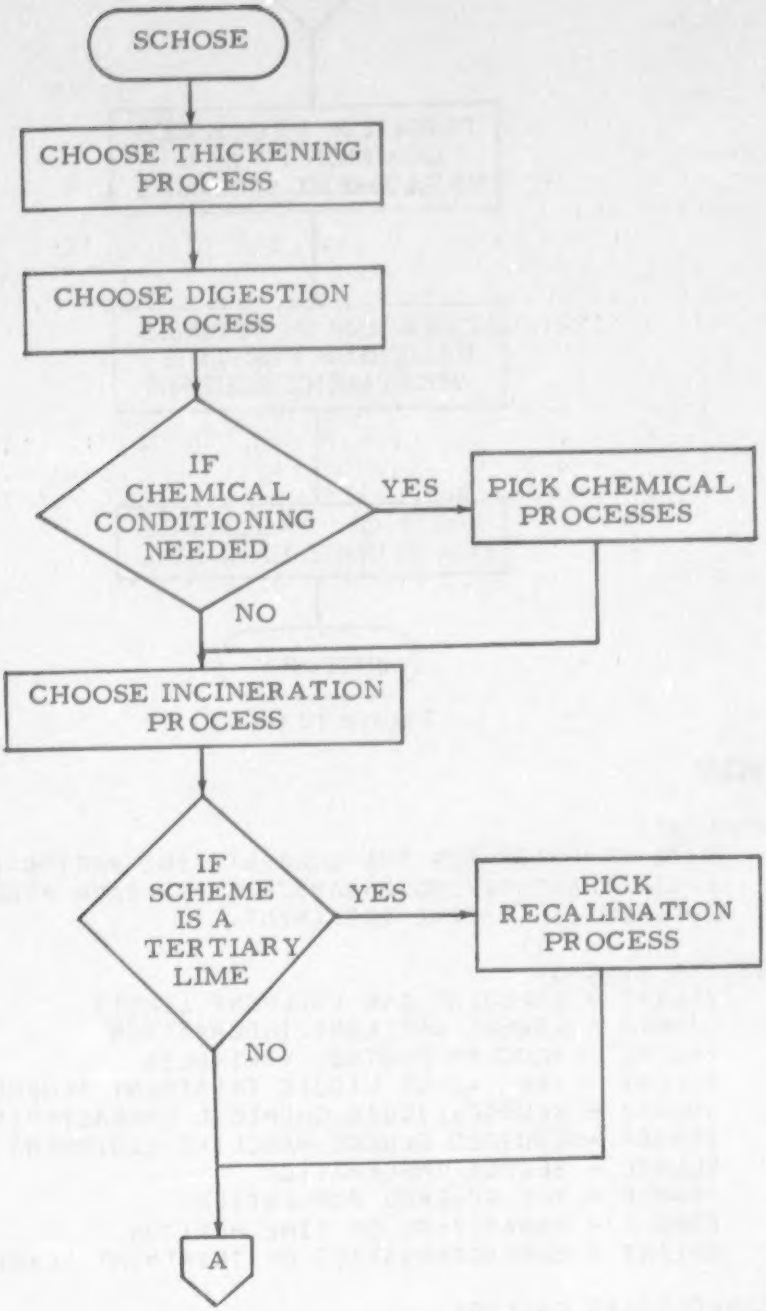

SCHOSE
CHOOSE THICKENING PROCESS
CHOOSE DIGESTION PROCESS
IF CHEMICAL CONDITIONING NEEDED
YES
PICK CHEMICAL PROCESSES
NO
CHOOSE INCINERATION PROCESS
IF SCHEME IS A TERTIARY LIME
YES
PICK RECALINATION PROCESS
NO
A

Figure 12

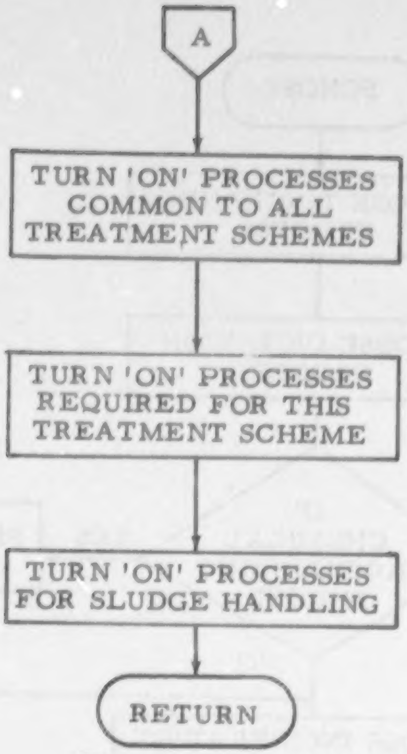

A
TURN 'ON' PROCESSES COMMON TO ALL TREATMENT SCHEMES
TURN 'ON' PROCESSES REQUIRED FOR THIS TREATMENT SCHEME
TURN 'ON' PROCESSES FOR SLUDGE HANDLING
RETURN

Figure 12 (cont.)

SIZE

```
PURPCSE:
   SIZE CCMPUTES FOR THE CURRENT TIME PERIOD (TP), THE
   INCEPENDENT SIZING PARAMETERS FOR EACH PROCESS WITH/WITHOUT
   PHCSPHORUS REMOVAL TREATMENT.

COMMCN BLCCKS:
   IELIMT - INFLUENT ANC EFFLUENT LIMITS
   LIQUIC - LIQUID INFLUENT INFCRMATICN
   PRGCNT - PROGRAM CONTROL VARIABLES
   SCHEME - INFC ABCUT LIQUIC TREATMENT SCHEMES
   SLCHAR - SLUDGE,LIQUIC,CHEMICAL CHARACTERISTICS
   SLGSCM -REQUIRED SLUDGE HANDLING EQUIPMENT
   SLUDGE - SLUDGE INFORMATICN
   SEWPOP - THE SEWERED POPULATICN
   TIME   - PARAMETERS OF TIME HORIZON
   TPLANT - CHARACTERISTICS OF TREATMENT PLANT PRCCESSES

SUBRCUTINES CALLED:
   TSCHME(ES) - INITIALIZES IN CRDER TO SIZE WPARM

CALLEC BY:
   TRTMNT - THE MAIN COSTING SUBRCUTINE

AUTHOR:
   DAVIC A BARNES   12OCT72
```

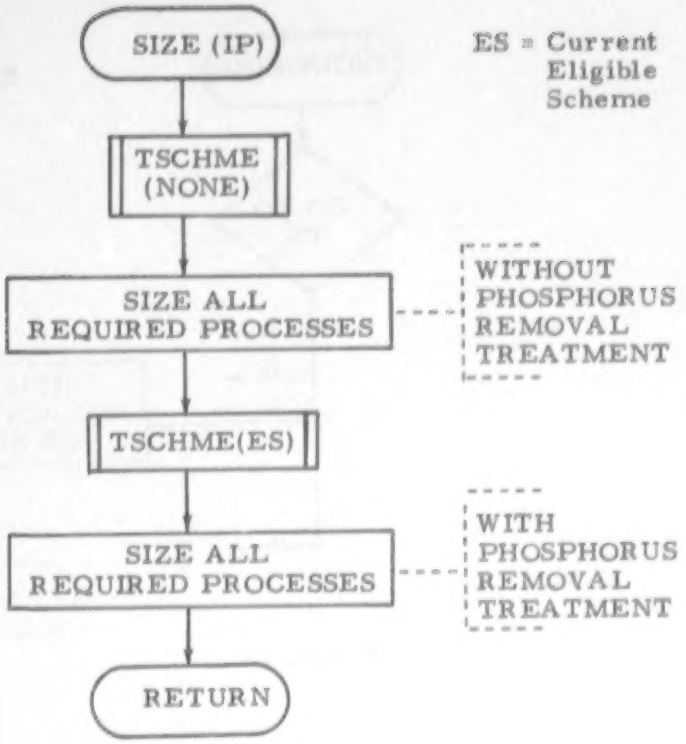

SIZE (IP)
ES = Current Eligible Scheme
TSCHME (NONE)
SIZE ALL REQUIRED PROCESSES
WITHOUT PHOSPHORUS REMOVAL TREATMENT
TSCHME(ES)
SIZE ALL REQUIRED PROCESSES
WITH PHOSPHORUS REMOVAL TREATMENT
RETURN

Figure 13

TSCHME(ES)

PURPOSE:
TSCHME INITIALIZES ALL THE DOMAIN VARIABLES NECESSARY TO SIZE WPARM(J) (THE INDEPENDENT SIZING PARAMETER WITH PHOSPHORUS REMOVAL TREATMENT FOR EACH PROCESS(J)). THIS IS DONE FOR A PARTICULAR ELIGIBLE TREATMENT SCHEME(ES).

COMMON BLOCKS:
LIQUID - LIQUID INFLUENT INFORMATION
PRGCNT - PROGRAM CONTROL VARIABLES
SLCHAR - SLUDGE,LIQUID,CHEMICAL CHARACTERISTICS
SLUDGE - SLUDGE CHARACTERISTICS
TPLANT - CHARACTERISTICS OF TREATMENT PROCESSES

CALLED BY:
SIZE - THE INDEPENDENT PARAMETER SIZING SUBROUTINE

AUTHOR:
DAVID A BARNES 13OCT72

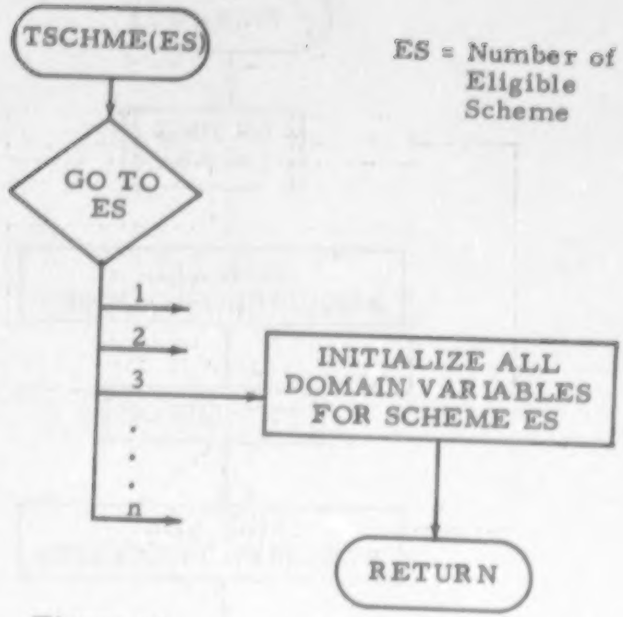

TSCHME(ES)
ES = Number of Eligible Scheme
GO TO ES
1
2
3
n
INITIALIZE ALL DOMAIN VARIABLES FOR SCHEME ES
RETURN

Figure 14

BUILD

```
PURPCSE:
   BUILC DETERMINES THE MAXIMUM SIZE CF THE NECESSARY
   ACDIT ICNAL EQUIPMENT NEEDED FOR EACH PROCESS AND THE TIME
   PERIOC WHEN ADDITICNAL EQUIPMENT IS FIRST NEEDED.

CCMMCN BLOCKS:
   PRGCNT - PROGRAM CONTROL VARIABLES
   TIME   - INFC ABCUT TIME HCRIZCN
   TPLANT - CHARACTERISTICS CF THE TREATMENT PLANT PRCCESSES
   TRTCST - TREATMENT CCSTS FCR EACH PROCESS FOR EACH TIME

CALLEC BY:
   TRTMNT - THE MAIN CCSTING SUBROUTINE

AUTHCR:
   DAVID A BARNES    19DEC72
```

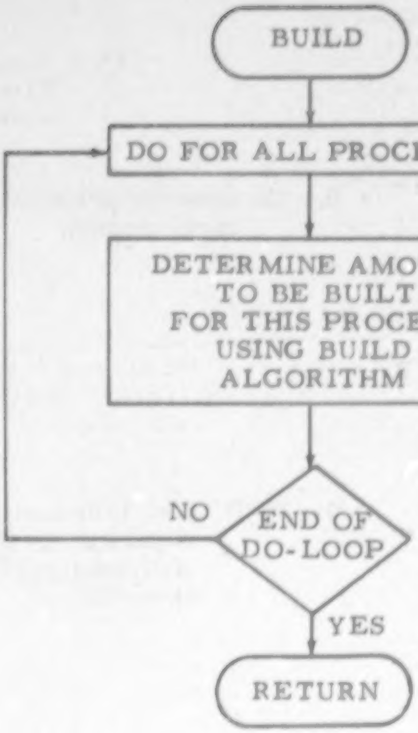

BUILD
DO FOR ALL PROCESSES
DETERMINE AMOUNT TO BE BUILT FOR THIS PROCESS USING BUILD ALGORITHM
NO
END OF DO-LOOP
YES
RETURN

Figure 15

PICTORIAL REPRESENTATION OF BUILD ALGORITHM

P = Present Plant sizing parameter for a process

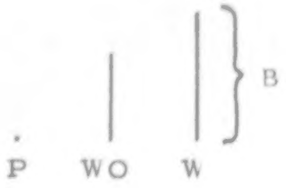
B = Size to be built

W = Size needed with Phosphorus Removal

WO = Size needed without P removal

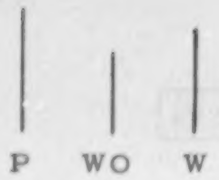
NOTE: Assume W > WO always

Case 1: $P = 0$



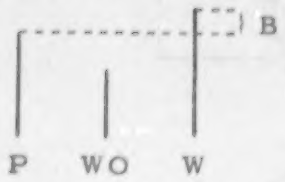
i.e. $B = W$

Case 2:



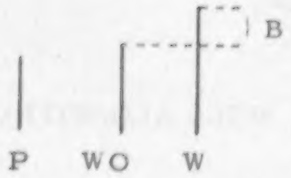
B = 0, because present size is large enough

Case 3:



B = W - P, i. e. the excess capacity, P - WO, is utilized for Phos. removal

Case 4:



B = W - WO, i. e. the amount, WO - P, which is also required is not caused by Phos. removal, but by population growth, and therefore its cost is not charged to Phos. removal

TRT1

PURPOSE:

THE COSTS ARE COMPUTED FOR EACH PROCESS WHICH IS BEING USED FOR THE CURRENT TREATMENT SCHEME IN THE FOLLOWING MANNER:

1. COSTS WHICH DEPEND ON THE SIZE OF THE PROCESS
   - A. IF $P \leqslant 0$, THEN COST = F(B)
   - B. IF $TP < TPFADD$, THEN COST = 0
   - C. IF $TP \geqslant TPFADD$, THEN COST = F(P + B) - F(P)
2. COSTS WHICH DEPEND ON ACTUAL USAGE OF THE PROCESS
   - A. IF $P \leqslant 0$, THEN COST = F(W)
   - B. OTHERWISE, COST = F(W) - F(WO)

P = PPARM = PRESENT SIZE OF PROCESS
B = BPARM = SIZE REQUIRED TO BE BUILT BY TIME PERIOD 'TPFADD'
W = WPARM = SIZE REQUIRED WITH PHOSPHORUS REMOVAL

WO = WOPARM = SIZE REQUIRED WITHOUT PHOSPHORUS REMOVAL

(SEE COMMON 'TPLANT' FOR ADDITIONAL EXPLANATION)

TRT2

PURPOSE:

TRT2 IS SIMILAR TO TRT1.

COMMON BLOCKS:

SUBROUTINES CALLED:

AUTHOR:

DAVID A. BARNES 30 NOV 72

CONCST

```
PURPOSE:
   CONCST COMPUTES CONSTRUCTION COSTS FOR EACH PROCESS
   NOTE: FOR MOST PROCESSES THE EQUATIONS ARE FROM REF. 10

COMMON BLOCKS:
   LBRCST - COST OF LABOR
   SCHEME - INFO ABOUT LIQUID TREATMENT SCHEMES
   TIME   - TIME HORIZON INFORMATION
   TPLANT - CHARACTERISTICS OF TREATMENT PLANT PROCESSES
   TRTCST - TREATMENT COSTS
   TSCST  - TIME AND SPACE DIFFERENCE COSTS

CALLED BY:
   TRTMNT - THE MAIN SIZING AND COSTING ROUTINE

REFERENCES:

AUTHOR:
   DAVID A. BARNES 30 NOV 72
```

LSKCST

```
PURPOSE:
   LSKCST CHOOSES A LIQUID SINK WITH A LARGE ENOUGH
   ASSIMILATIVE PHOSPHORUS CAPACITY.  IT THEN COMPUTES THE
   PUMP AND PIPE REQUIREMENTS.  AND THEN CALCULATES THE COST
   OF THE SINK FOR EACH TIME PERIOD.

COMMON BLOCKS:
   ENGCST - DELIVERED COSTS OF ENERGY FORMS
   IELIMT - INFLUENT/EFFLUENT LIMITS
   LIQUID - LIQUID INFLUENT INFORMATION
   LSINK  - CHARACTERISTICS OF LIQUID SINKS
   PRGCNT - PROGRAM CONTROL VARIABLES
   SEWPOP - THE SEWERED POPULATION

CALLED BY:
   REMOVE - THE MAIN PROGRAM

AUTHOR:
   DAVID A BARNES   12OCT72
```

LSKCST
DUMMY FOR NOW
RETURN

Figure 16

SSKCST

```
PURPOSE:
   SSKCST COMPUTES THE COST OF TRANSPORTING THE SOLID WASTE
   FROM THE TREATMENT PLANT TO A SINK WITH SUFFICIENT CAPACITY.
   THIS IS DONE FOR EACH TIME PERIOD.

COMMON BLOCKS:
   PRGCNT - PROGRAM CONTROL VARIABLES
   SSINK  - CHARACTERISTICS OF THE SOLID SINKS

CALLED BY:
   REMOVE - THE MAIN PROGRAM

AUTHOR:
   DAVID A BARNES   12OCT72
```

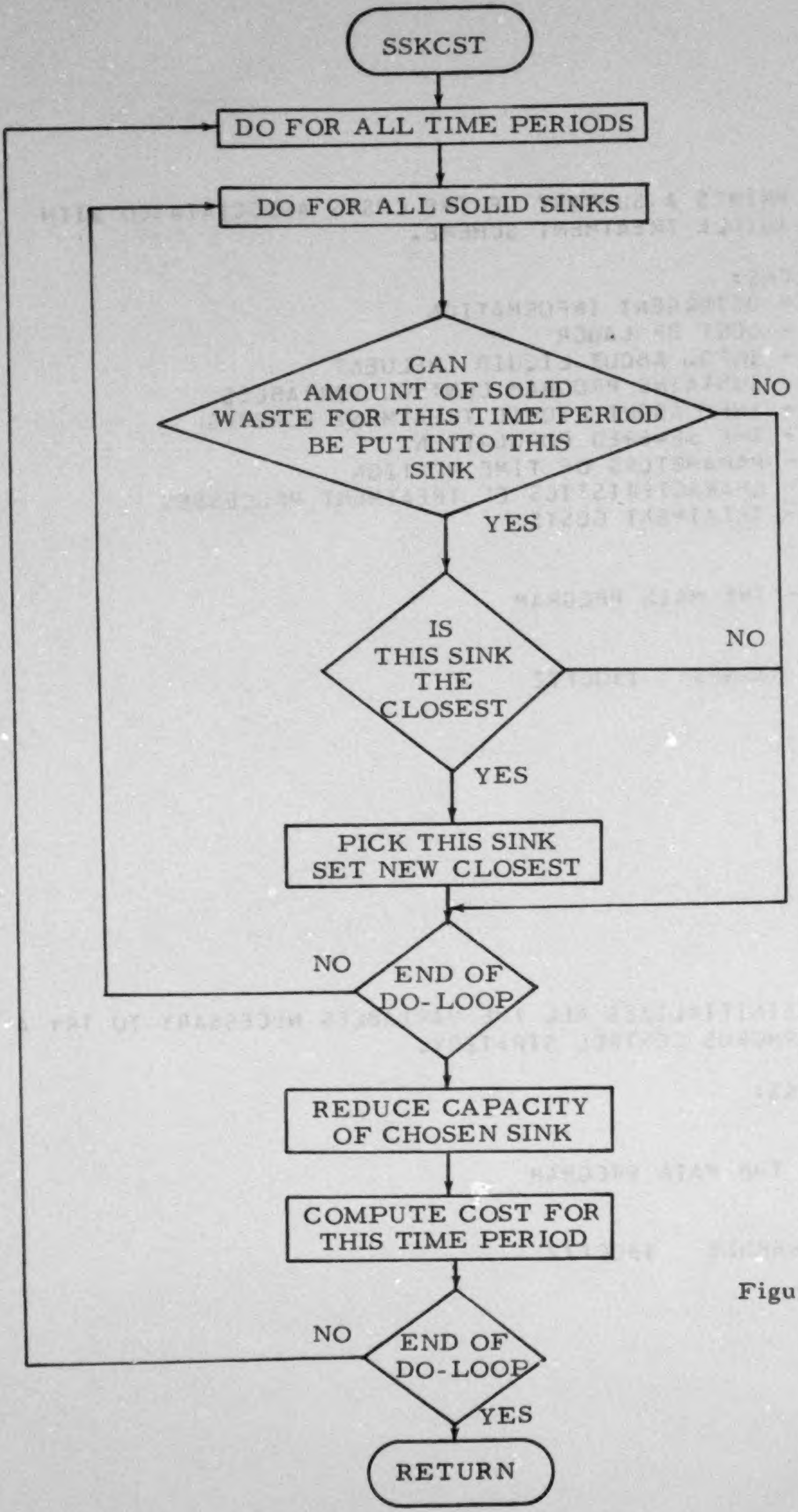

SSKCST
DO FOR ALL TIME PERIODS
DO FOR ALL SOLID SINKS
CAN AMOUNT OF SOLID WASTE FOR THIS TIME PERIOD BE PUT INTO THIS SINK
NO
YES
IS THIS SINK THE CLOSEST
NO
YES
PICK THIS SINK SET NEW CLOSEST
NO
END OF DO-LOOP
REDUCE CAPACITY OF CHOSEN SINK
COMPUTE COST FOR THIS TIME PERIOD
NO
END OF DO-LOOP
YES
RETURN

Figure 17

REPORT

PURPOSE:
REPORT PRINTS A SUMMARY OF THE COSTS ASSOCIATATED WITH EACH ELIGIBLE TREATMENT SCHEME.

COMMON BLOCKS:
DTRGNT - DETERGENT INFORMATION
LBRCST - COST OF LABOR
LIQUID - INFO. ABOUT LIQUID INFLUENT
PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
SCHEME - INFO ABOUT LIQUID TREATMENT SCHEMES
SEWPOP - THE SEWERED POPULATION
TIME - PARAMETERS OF TIME HORIZON
TPLANT - CHARACTERISTICS OF TREATMENT PROCESSES
TRTCST - TREATMENT COSTS

CALLED BY:
REMOVE - THE MAIN PROGRAM

AUTHOR:
DAVID A BARNES 13OCT72

REINIT

PURPOSE:
REINIT REINITIALIZES ALL THE VARIABLES NECESSARY TO TRY A NEW PHOSPHORUS CONTROL STRATEGY.

COMMON BLOCKS:

CALLED BY:
REMOVE - THE MAIN PROGRAM

AUTHOR:
DAVID A BARNES 13OCT72

Common Block Descriptions

```
COMMON BLOCK:
   CHMCST

PURPOSE:
   CONTAINS DELIVERED COST OF CHEMICALS

VARIABLES:
   ALUMCS - COST OF ALUM
   CO2CS  - COST OF CARBON DIOXIDE
   FECLCS - COST OF FERRIC CHLORIDE
   LIMECS - COST OF LIME
   NAALCS - COST OF SODIUM ALUMINATE
   NAOHCS - COST OF SODIUM HYDROXIDE
   PCKLCS - COST OF PICKLE LIQUOR
   POLYCS - COST OF POLYMER

AUTHOR:
   RON ORNER     10 OCT 72




COMMON BLOCK:
   DTRGNT

PURPOSE:
   CONTAINS DETERGENT INFORMATION

VARIABLES:
   DIFCOS  - DIFFERENTIAL COST OF PHOSPHATE SUBSTITUTE ($/LB)
   DTRGUS  - ANNUAL PER CAPITA DETERGENT USE (LBS/CAP/YR)
   ENFCST  - ANNUAL PER CAPITA ENFORCEMENT COSTS OF P BAN ($/CA
   PDRATO  - RATIO PHOSPHATE TO DETERGENT WEIGHT
   PDTRG   - WEIGHT P IN SEWAGE DUE TO DETERGENTS (LBS)
   PPRATO  - RATIO PHOSPHORUS TO PHOSPHATE
   PRESPC  - PRESENT P CONCENTRATION IN DETERGENTS (RATIO)
   PSUBCS(TP) - COST OF P SUBSTITUTE FOR EACH TIME PERIOD ($)

AUTHOR:
   RON ORNER     10 OCT 72
```

```
COMMON BLOCK:
   ENGCST

PURPOSE:
   CONTAINS DELIVERED COSTS OF ENERGY SUPPLIES

VARIABLES:
   ELECOS - ELECTRICITY COST ($/KWHR)
   OILCOS - OIL COST         ($/GAL )
   GASCOS - GAS COST         ($/CU.FT)

AUTHOR:
   RON ORNER     10 OCT 72

COMMON /ENGCST/ ELECOS, OILCOS, GASCOS
```

```
COMMON BLOCK:
   IELIMT

PURPOSE:
   CONTAINS INFLUENT AND EFFLUENT CONCENTRATIONS
   OF PHOSPHORUS

VARIABLES:
   IELIMT(I,J) - I=1: INFLUENT CONCENTRATION (MG/L)
                 I=2: EFFLUENT CONCENTRATION (MG/L)
                 J  : TIME PERIOD
   EFF         - EFFLUENT CONCENTRATION INDEX
   INF         - INFLUENT CONCENTRATION INDEX

AUTHOR:
   RON ORNER     10 OCT 72
```

```
COMMON BLOCK:
   INDSTY

PURPOSE:
   CONTAINS INDUSTRIAL PHOSPHORUS INFORMATION. This common block
   is unused since it is referenced only by the dummy subroutine INDLIM.
VARIABLES:
   INDSTY(I,J) - I=1: LBS P/DAY OUTPUT OF INDUSTRY J
                 I=2,3: 8 CHARACTER NAME FOR INDUSTRY J
   LEGINP      - LEGISLATED P LEVEL FOR INDUSTRY (MG/L)

AUTHOR:
   RON ORNER    10 OCT 72


COMMON BLOCK:
   LBRCST

PURPOSE:
   CONTAINS LABOR COSTS

VARIABLES:
   DHR    - DIRECT HOURLY RATE  ($/HR)
   IDFRAC - INDIRECT FRACTION OF DIRECT LABOR

AUTHOR:
   RON ORNER    10 OCT 72


COMMON BLOCK:
   LIQUID

PURPOSE:
   CONTAINS THE CHARACTERISTICS OF LIQUID INFLUENT SEWAGE.

VARIABLES:
   ALKIPS  - ALKALINITY CONC. INTO PRIMARY SETTLER (CACO3 MG/L)
   BODIPS  - BOD5 CONC. INTO PRIMARY SETTLER (MG/L)
   MLSSAR  - MIXED LIQUOR SUSPENDED SOLIDS IN AER. PROC. (MG/L)
   NH3IAR  - NH3 CONC. INTO AERATION PROCESS (MG/L)
   PINPS   - PHOSPHORUS CONC. INTO PRIMARY SETTLER (MG/L)
   QAVE    - PRESENT AVERAGE DAILY FLOW (MGD)
   QPEAK   - PRESENT PEAK DIURNAL FLOW (MGD)
   SSINPS  - SUSPENDED SOLIDS CONC. INTO PRIMARY SETTLER (MG/L)
   TBODAR  - TOTAL CHANGE IN BOD5 ACROSS AERATION PROCESS
             (FRACTION REMOVED)

AUTHOR:
   DAVID A BARNES   26 DEC 72
```

```
COMMON BLOCK:
   PRNTR

PURPOSE:
   PRNTR CONTAINS VARIABLES CONTROLLING THE PRINTOUT

VARIABLES:
   IPASS   - =1, FIRST SET OF PASSES THRU ELIGIBLE
                 SCHEME LOOP
             =2, TO GET SELECTED LONG PRINTOUTS
   ISELCT(J) - NUMBERS OF SCHEMES SELECTED FOR LONG PRINTOUT
                 FOLLOWING SHORT OR SUPERSHORT
                 PRINTOUT OF ALL ELIGIBLE SCHEMES
   ISHORT  - =ON, FOR SHORT OR SUPERSHORT PRINTOUT
             =OFF, FOR LONG PRINTOUT
   ISKIP   - SET TO ON FIRST TIME THRU REPORT
             SET TO OFF BY REMOVE
   ISUPER  - =ON, FOR SUPERSHORT PRINTOUT
             =OFF, OTHERWISE

AUTHOR:
   DAVID A BARNES     4 JAN 73
```

```
COMMON BLOCK:
   LSINK

PURPOSE:
   LIQUID SINK COSTS

VARIABLES:
   BESTLS(TP)  - ORDINAL OF LIQUID SINK USED FOR TIME PERIOD TP
   LIQSNK(I,J) - I=1: ASSIMILATIVE CAPACITY OF SINK J (LBS P/YR
                 I=2: HEAD LOSS TO SINK J (FT)
                 I=3: DISTANCE TO SINK J (FT)
   LSNKCS(TP)  - COST OF LIQUID SINK USED FOR TIME PERIOD TP

AUTHOR:
   RON ORNER    10 OCT 72


COMMON BLOCK:
   PRGCNT

PURPOSE:
   PRGCNT CONTAINS VARIABLE USED BY THE PROGRAM REMOVE
   AND ITS SUBROUTINES TO CONTROL THE FLOW OF DECISIONS

VARIABLES:
   ISCHM - DO-LOOP VARAIBLE (SCHEME NUMBER)
   ITYPE  - KIND OF VALUE OF TYPED IN ANWERS
          = FIXED = 1 INTEGER
          = FLOTE = 2 FLOATING POINT
          = ALPHA = 3 ALPHANUMERIC
   IGOTO  - USED IN COMPUTED GO TO TO SIMULATE MULTILE
            RETURNS FROM SUBROCTUINES
   IANSWR - WILL CONTAIN FIXED VALUE TYPED IN
   ANSWER - WILL CONTAIN FLOAT VALUE TYPED IN
```

```
COMMON BLOCK:
   SCHEME

PURPOSE:
   CONTAINS PARAMETERS FOR PHOSPHORUS REMOVAL SCHEMES

VARIABLES:
   ELGBTY(J) - =ON IF SCHEME J IS ELIGIBLE, =OFF OTHERWISE
   EQUIP(K) - EQUIP(K)=ON IF PROCESS K IS NECESSARY FOR THIS
   STRATEGY, =OFF IF NOT
   MAXSCM - THE MAXIMUM NUMBER OF SCHEMS, MAX VALUE OF J
   MINEFP(J) - MINUMUM ACHIEVABLE EFFLUENT P CONC. FOR
               SCHEME J
   SCHEME(I.J) - I PARAMETERS FOR J SCHEMES
                 I REPRESENTS REQUIRED LIQID EQUIPMENT FOR
                 SCHEME J - SEE COMMON /TPLANT/

   J   NAME    DESCRIPTION OF SCHEME
   1   ALPYPS  ALUM + POLYMER TO PRIMARY SETTLER
   2   FCPYPS  FERRIC CHLORIDE + POLYMER TO PRIMARY SETTLER
   3   FCLMPS  FERROUS CHLORIDE + LIME TO PRIMARY SETTLER
   4   LIMEPS  LIME TO PRIMARY SETTLER
   5   ALPYFB  ALUM + POLYMER TO FLOCCULATION BASIN
   6   FCPYFB  FERRIC CHLORIDE + POLYMER TO FLOCC. BASIN
   7   FCLMFB  FERROUS CHLORIDE + LIME TO FLOCC. BASIN
   8   LIMEFB  LIME TO THE FLOCCULATION BASIN
   9   ALUMAB  ALUM THE THE AERATION BASIN
   10  FECLAB  FERRIC CHLORIDE TO AERATION BASIN
   11  NAALAB  SODIUM ALUMINATE TO AERATION BASIN
   12  ALABMF  ALUM TO AER. BASIN + MULTI-MEDIA FILTRATION
   13  FCABMF  FERRIC CHLORIDE TO AER. BASIN + MULTI-MEDIA FIL.
   14  NAABMF  SODIUM ALUMINATE TO AER. BASIN + MUL-MED FILTR.
   15  ALUMTF  ALUM AFTER TRICKLING FILTER
   16  FECLTF  FERRIC CHLORIDE AFTER TRICKLING FILTER
   17  ALTFMF  ALUM AFTER TRICKLING FILTER + MUL-MED FILTR.
   18  FCTFMF  FERRIC CHLORIDE AFTER TRK.FIL. + MUL-MED FILTR.
   19  ALFBAS  ALUM TO FLOCC. AFTER CONVENTIONAL SECONDARY
   20  FCFBAS  FECL3 TO FLOCC. AFTER CONVENTIONAL SECONDARY
   21  L1FBAS  LIME(1-STAGE)  TO FLOCC AFTER CONVEN. SECONDARY
   22  L2FBAS  LIME(2-STAGE)  TO FLOCC AFTER CONVEN. SECONDARY
   23  NONE    NO CHEMICALS ADDED FOR PHOSPHORUS REMOVAL

AUTHOR:
   RON ORNER     10 OCT 72
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COMMON BLOCK:
   SEWPOP

PURPOSE:
   CONTAINS INFORMATION ABOUT PRESENT AND FUTURE SEWERED
   POPULATION.

VARIABLES:
   FNCTYP   - THE TYPE OF FUTURE SEWERED POPULATION GROWTH FUNC.
              =1 ASSUMED LINEAR 5 PERCNT GROWTH RATE
              =2 LINEAR
              =3 EXPONENTIAL
              =4 PIECE-WISE LINEAR

   SPOPIN(I,J) - THE SEWERED POPS AND YEARS READ IN

                    I=1  THE SEWERED POP
                    I=2  THE YEAR
                    J    THE ORDINAL FOR POP AND VALUES READ IN

   SEWPOP (TP) - THE SEWERED POPULATION FOR EACH TIME PERIOD

   MAXPV - THE MAXIMUM SIZE OF J IN SPOPIN(I,J)
   SPOP  - THE SEWERED POPULATION INDEX
   YEAR  - THE YEAR INDEX

AUTHOR:
   DAVID A BARNES   03OCT72
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COMMON BLOCK:
   SLCHAR
PURPOSE:
   CONTAINS CHARACTERISTICS OF THE SLUDGE, LIQUID, AND CHEMICAL
   STREAMS DURING PLANT OPERATION.
VARIABLES:
   AARATO - POUNDS OF ALUM (OR NAAL)/POUND OF AL
   ADDSSR - ADDITIONAL SUSPENDED SOLIDS REMOVAL (MG/L)
   ALKIAR - ALKALINITY IN AERATION PROCESS (MG CACO3/L)
   BODIAR - BOD5 INTO AERATION PROCESS (MG/L)
   CO2D   - CO2 DOSE IN RECARBONATION (LBS CO2/MIL. GAL.)
   FCVFD  - FECL3 DOSAGE FOR VACUUM FILTER (LBS/TON)
   FERATO - POUNDS OF FECL3 (OR PCKL)/POUND OF FE
   LBNVPS - POUNDS OF NON-VOLATILE PRIMARY   SLUDGE (LBS/DAY)
   LBNVSS - POUNDS OF NON-VOLATILE SECONDARY SLUDGE (LBS/DAY)
   LBNVTS - POUNDS OF NON-VOLATILE TERTIARY  SLUDGE (LBS/DAY)
   LBVPS  - POUNDS OF VOLATILE PRIMARY   SLUDGE (LBS/DAY)
   LBVSS  - POUNDS OF VOLATILE SECONDARY SLUDGE (LBS/DAY)
   LBVTS  - POUNDS OF VOLATILE TERTIARY  SLUDGE (LBS/DAY)
   LIMEPD - LIME PRIMARY DOSAGE (MG/L)
   LIMETD - LIME TERTIARY DOSE (MG/L)
   LMVFD  - LIME DOSAGE FOR VACUUM FILTER (LBS/TON)
   PALUM  - TOTAL AMOUNT OF ALUM USED FOR 1 TP (LBS)
   PCO2   - TOTAL AMOUNT OF CO2  USED FOR 1 TP (LBS)
   PFECL  - TOTAL AMOUNT OF FECL USED FOR 1 TP (LBS)
   PLIME  - TOTAL AMOUNT OF LIME USED IN 1 TP (LBS)
   PNAAL  - TOTAL AMOUNT OF NAAL USED FOR 1 TP (LBS)
   PNAOH  - TOTAL AMOUNT OF NAOH USED FOR 1 TP (LBS)
   POLYD  - POLYMER PRIMARY DOSAGE (MG/L)
   PPOLY  - TOTAL AMOUNT OF POLY USED FOR 1 TP (LBS
   PPCKL  - TOTAL AMOUNT OF PCKL USED FOR 1 TP (LBS
   PYFTD  - POLYMER DOSE FOR FLOTATION THICKENER (LBS/TON)
   PYVFD  - POLYMER DOSE FOR VACUUM FILTRATION (LBS/TON)
   QPSLGE - VOLUME OF PRIMARY   SLUDGE (MGD)
   QSSLGE - VOLUME OF SECONDARY SLUDGE (MGD)
   QTOTAL - VOLUME OF TOTAL     SLUDGE (MGD)
   QTSLGE - VOLUME OF TERTIARY  SLUDGE (MGD)
   SRALF  - SLUDGE RATIO IN TRICKLING FILTER (LBS/LB AL)
   SRALP  - SLUDGE RATION IN PRIMARY (LBS/LB AL)
   SRCAT  - SLUDGE RATIO FOR CATION (LBS SLUDGE/LBS CATION)
   SRCATA - SLUDGE RATIO IN AERATOR (LBS/LBS FE)
   SRCATS - SLUDGE RATIO IN SECONDARY EFFLUENT (LBS/LB CATION)
   SRFEF  - SLUDGE RATIO IN TRICKLING FILTER (LBS/LB FE)
   SRFEP  - SLUDGE RATIO IN PRIMARY (LBS/LB FE)
   SRLIME - SLUDGE RATIO FOR LIME   (LBS SLUDGE/MG)
   SRTLIM - SLUDGE RATIO FOR LIME (TERTIARY) (LBS SLUDGE/MG)
   TLBNVS - TOTAL POUNDS OF NON-VOLATILE SLUDGE (LBS/DAY)
   TLBPS  - TOTAL POUNDS OF PRIMARY      SLUDGE (LBS/DAY)
   TLBSLG - TOTAL POUNDS OF ALL          SLUDGE (LBS/DAY)
   TLBSS  - TOTAL POUNDS OF SECONDARY    SLUDGE (LBS/DAY)
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      TLBTS  - TOTAL POUNDS OF TERTIARY     SLUDGE (LBS/DAY)
      TLBVS  - TOTAL POUNDS OF VOLATILE     SLUDGE (LBS/DAY)
      TSETUC - TERTIARY SETTLER UNDERFLOW DENSITY (FRACTION)
      WOLBSS - = TLBSS (WITHOUT P REMOVAL) (LBS/DAY)
      WOPALM - = PALUM (WITHOUT P REMOVAL) (LBS)
      WOPCO2 - = PCO2  (WITHOUT P REMOVAL) (LBS)
      WOPFC  - = PFECE (WITHOUT P REMOVAL) (LBS)
      WOPLIM - = PLIME (WITHOUT P REMOVAL) (LBS)
      WOPNAL - = PNAAL (WITHOUT P REMOVAL) (LBS)
      WOPNOH - = PNAOH (WITHOUT P REMOVAL) (LBS)
      WOPPLY - = PPOLY (WITHOUT P REMOVAL) (LBS)
      WOTLBS - TOTAL POUNDS OF SLUDGE WITHOUT P REMOVAL
      WOPPCK - = PPCKL (WITHOUT P REMOVAL (LBS)
      WRALA  - WEIGHT RATIO AL/P IN AERATOR
      WRALF  - WEIGHT RATIO AL/P IN TRICKLING FILTER
      WRALP  - WEIGHT RATIO AL/P IN PRIMARY
      WRALS  - WEIGHT RATIO AL/P TO SECONDARY
      WRCAT  - WEIGHT RATIO OF CATION TO PHOSPHORUS
      WRCATS - WEIGHT RATIO OF CATION TO PHOSPHORUS IN SEC. EFF.
      WRFEA  - WEIGHT RATIO FE/P IN AERATOR
      WRFEF  - WEIGHT RATIO FE/P IN TRICKLING FILTER
      WRFEP  - WEIGHT RATIO FE/P IN PRIMARY
      WRFES  - WEIGHT RATIO FE/P TO SECONDARY
   AUTHOR:
      DAVID A BARNES   14NOV72


   COMMON BLOCK:
      SLGSCM

   PURPOSE:
      CONTAINS REQUIRED SLUDGE HANDLING EQUIP. FOR LIQUID TREAT.
      SCHEMES

   VARIABLES:
      SLGSCM(I) - NUMBERS REPRESENTING SLUDGE HANDLING EQUIP.
                  (INITIALIZED TO ZERO AND FILLED BY SCHOSE
                   - SEE COMMON /TPLANT/ )

   AUTHOR:
      RON CRNER     10 OCT 72
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COMMON BLOCK:
   SLUDGE

PURPOSE:
   CONTAINS CHARACTERISTICS OF SLUDGE.

VARIABLES:
   ASC    - ACTIVATED SLUDGE DENSITY (FRACTION)
   FLOTUC - FLOTATION THICKENER UNDERFLOW SLUDGE DENSITY (FRAC)
   GRAVUC - GRAVITY THICKENER UNDERFLOW SLUDGE DENSITY (FRAC)
   HPDFT - OPERATING HOURS PER DAY FOR FLOTATION THICKENER
   HPDVF - OPERATING HOURS PER DAY FOR VACUUM FILTER
   PSETUC - PRIMARY SETTLER UNDERFLOW SLUDGE DENSITY (FRAC)
   PSRMVE - SOLIDS REMOVAL IN PRIMARY SETTLER (FRACTION)
   VFPSLG  - VOLATILE FRACTION FOR PRIMARY SLUDGE (FRACTION)
   VSANRM  - VOLATILE SLUDGE REMAINING AFTER ANAEROBIC
             DIGESTION (FRACTION)
   VSARM - VOLATILE SLUDGE REMAINING AFTER AEROBIC DIGESTION
   (FRACTION)
AUTHOR:
   DAVID A BARNES   03OCT72


COMMON BLOCK:
   SSINK

PURPOSE:
   SOLID SINK CHARACTERISTICS

VARIABLES:
   BESTSS(TP) - ORDINAL OF SOLID SINK USED AT TP
   CAP     - CAPACITY INDEX
   DIST    - DISTANCE INDEX
   MAXSS   - MAXIMUM NUMBER OF SOLID SINKS
   SOLSNK(I,J) - I=1: CAPACITY OF SINK J
                 I=2: DISTANCE TO SINK J
   SSCOST(TP) - COST OF SOLID SINK USED AT TP ($)
   SWASTE(TP) - SOLID WASTE FROM TREATMENT PLANT AT TIME TP
                                                      (TONS)
   TRNCST - TRANSPORTATION COST OF SOLID WASTE ($/TON/MILE)

AUTHOR:
   RON ORNER     10 OCT 72
```

COMMON BLOCK:
TIME

PURPOSE:
CONTAINS INFORMATION ABOUT TIME HORIZON OF CONTROL STRATEGY

VARIABLES:
NOYRS - NUMBER OF YEARS FOR CONTROL STRATEGY
MAXTP - MAXIMUM NUMBER OF TIME PERIODS = NOYEARS/TPSIZE
TPSIZE - SIZE OF TIME PERIOD STEPS (FRACTION OF YEARS)
TP - THE CURRENT TIME PERIOD

AUTHOR:
DAVID A BARNES 03OCT72

COMMON BLOCK:
TPLANT

PURPOSE:
CONTAINS TREATMENT PARAMETERS FOR TREATMENT PROCESSES

VARIABLES:
TPLANT(I,J) - I PARAMETERS FOR TREATMENT PROCESS J

J	VARIABLE	DESCRIPTION
1	RWPUMP	RAW WASTEWATER PUMPING
2	PRETRT	PRELIMINARY TREATMENT
3	PRMSET	PRIMARY SETTLER
4	PSPUMP	PRIMARY SLUDGE PUMPING
5	TRKFTR	TRICKLING FILTER (SINGLE MEDIA)
6	AERBSN	AERATION BASIN
7	DIFAIR	DIFFUSED AIR SYSTEM
8	MCHAER	MECHANICAL AERATION
9	FLOCCP	FLOCCULATION BEFORE PRIMARY
10	SECSET	SECONDARY SETTLER
11	RE1PMP	RECIRCULATION PUMPING
12	CLFEED	CHLORINE FEED SYSTEM
13	CLBASN	CHLORINATION CONTACT BASIN
14	MULFTR	MULT-MEDIA FILTER
15	RE2PMP	RECIRCULATION PUMPING
16	GRVTKN	GRAVITY THICKNER
17	FLOTKN	AIR FLOTATION THICKNER
18	ANADIG	ANAEROBIC DIGESTION
19	AERDIG	AEROBIC DIGESTION
20	DRYBED	SLUDGE DRYING BED
21	SLDTNK	SLUDGE HOLDING TANK
22	VACFTR	VACUUM FILTER

```
 23   CENFUG     CENTRIFUGE
 24   MHINC      MULTIPLE HEARTH INCINERATOR
 25   FBINC      FLUIDIZED BED INCINERATOR
 26   WSPOND     WASTE STABILIZATION POND
 27   SLGOON     SLUDGE LAGOON
 28   RECRB1     RE-CARBINATION
 29   RECRB2     RE-CARBINATION
 30   TERST1     TERTIARY SETTLER
 31   TERST2     TERTIARY SETTLER
 32   ALUMFS     ALUM              FEEDING AND STORAGE
 33   FECLFS     FERRIC CHLORIDE   FEEDING AND STORAGE
 34   LIMEFS     LIME              FEEDING AND STORAGE
 35   POLYFS     POLYMER           FEEDING AND STORAGE
 36   CO2FS      CO2               FEEDING AND STORAGE
 37   NAALFS     SODIUM ALUMINATE  FEEDING AND STORAGE
 38   PCKLFS     PICKLING LIQUOR   FEEDING AND STORAGE
 39   NAOHFS     SODIUM HYDROXIDE  FEEDING AND STORAGE
 40   RECALC     RECALCINATION
 41   FLOCCT     FLOCCULATION BEFORE TERTIARY
 42
 43
 44
 45
```

PARAMETERS FOR TREATMENT PROCESSES

```
  I   VARIABLE   DESCRIPTION

  1   PNAME      12 CHARACTER DESCRIPTION OF PROCESS
  2   PNAME      12 CHARACTER DESCRIPTION OF PROCESS
  3   PNAME      12 CHARACTER DESCRIPTION OF PROCESS
  4   AMRATE     AMORTIZATION RATE
  5   AMLIFE     AMORTIZATION LIFETIME
  6   PPARM      PRESENT INDEPENDENT SIZING PARAMETER FOR COSTS
  7   PVAR       PRESENT DESIGN PARAMETER
  8   WOPARM     INDEPENDENT SIZING PARAMETER WITHOUT P REMOVAL
  9   WPARM      INDEPENDENT SIZING PARAMETER WITH P REMOVAL
 10   WVAR       DESIGN PARAMETER WITH P REMOVAL
 11   BPARM      INDEPENDENT SIZING PARAMETER TO BE BUILT
 12   BASE       AMAX1(WOPARM,PPARM), USED BY O+M COST EQS.
 13   APVAR      INITIAL ASSUMED VALUE OF PVAR
 14   PARMX      FOUR CHARACTER DESCRIPTION OF PARM
 15   MINRV      MINIMUM USABLE VALUE OF BPARM
 16   MAXRV      MAXIMUM USABLE VALUE OF BPARM
```

```
DESCRIPTIONS AND DIMENSIONS OF PARM AND VAR FOR EACH
PROCESS FOLLOW:
   PARM = INDEPENDENT SIZING PARAMETER
   VAR = DESIGN VARIABLE

  RWPUMP: PARM - INITIAL FIRM CAPACITY (MGD)
  PRETRT: PARM - MAXIMUM CAPACITY (MGD)
  PRMSET: PARM - SURFACE AREA OF SETTLER (THOS. SQ. FT.)
          VAR -  DESIGN OVERFLOW RATE(GPD/SQ.FT.)
  PSPUMP: PARM - INITIAL FIRM CAPACITY (GPM)
          VAR -  OPERATING HOURS (HOURS/DAY)
  TRKFTR: PARM - MEDIA VOLUME (THOS. CU. FT.)
          VAR -  HYDRALIC LOADING (MGD/ACRE)
  AERBSN: PARM - LIQUID VOLUME (THOS. CU. FT.)
          VAR -  DETENTION TIME (HOURS)
  DIFAIR: PARM - INITIAL FIRM BLOWER CAPACITY (THOS. CFM)
          VAR -  DIFFUSER EFFICIENCY (FRACTION)
  MCHAER: PARM - TOTAL INSTALLED CAPACITY (HP)
          VAR -  TRANSFER EFFICIENCY (LBS O2/HP-HR)
  FLCCCP: PARM - MAXIMUM CAPACITY (MGD)
  SECSET: PARM - SURFACE AREA OF SETTLER (THOS. SQ. FT.)
          VAR -  DESIGN OVERFLOW RATE (GPD/SQ.FT.)
  RE1PMP: PARM - MAXIMUM CAPACITY (MGD)
  CLFEED: PARM - AVERAGE CHLORINE USE (LBS/DAY)
          VAR -  CHLORINE DOSAGE (MG/L)
  CLBASN: PARM - LIQUID VOLUME (THOS. CU. FT.)
          VAR -  CHLORINE CONTACT TIME (MINUTES)
  MULFTR: PARM - CAPACITY (MGD)
  RE2PMP: PARM - MAXIMUM CAPACITY (MGD)
  GRVTKN: PARM - SURFACE AREA (THOS. SQ. FT.)
          VAR -  DESIGN LOADING RATE (LBS/SQ.FT.)
  FLOTKN: PARM - SURFACE AREA (SQ. FT.)
          VAR -  LOADING RATE (LB/HR/SQ.FT.)
  ANADIG: PARM - SLUDGE VOLUME (THOS. CU. FT.)
          VAR -  DETENTION TIME (DAYS)
  AERDIG: PARM - SLUDGE VOLUME (THOS. CU. FT.)
          VAR -  DETENTION TIME (DAYS)
  DRYBED: PARM - SURFACE AREA OF BEDS (THOS. SQ. FT.)
          VAR -  REQUIRED BED AREA (SQ.FT./CAPITA)
  SLDTNK: PARM - SLUDGE VOLUME (THOS. CU. FT.)
          VAR -  DETENTION TIME (HOURS)
  VACFTR: PARM - FILTER AREA (SQ. FT.)
          VAR -  LOADING RATE (LBS/HR/SQ.FT.)
  CENFUG: PARM - FIRM CAPACITY (GPM)
          VAR -  OPERATING TIME (FRACTION OF DAY)
  MHINC:  PARM - CAPACITY (LBS DRY SOLIDS/HR)
          VAR -  OPERATING TIME (HOURS/DAY)
  FBINC:  PARM - CAPACITY (LBS DRY SOLIDS/HR)
          VAR -  OPERATING TIME (HOURS/DAY)
```

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      WSPOND: PARM - SLUDGE VOLUME (THOS. CU. FT.)
              VAR -  DETENTION TIME (DAYS)
      SLGDCN: PARM - SLUDGE VOLUME (THOS. CU. FT.)
              VAR -  DETENTION TIME (DAYS)
      RECRB1: PARM - LIQUID VOLUME (THOS. CU. FT.)
              VAR -  DETENTION TIME (MINUTES)
      RECRB2: PARM - LIQUID VOLUME (THOS. CU. FT.)
              VAR -  DETENTION TIME (MINUTES)
      TERST1: PARM - SURFACE AREA OF SETTLER (THOS. SQ. FT.)
              VAR -  DESIGN OVERFLOW RATE (GPD/SQFT)
      TERST2: PARM - SURFACE AREA OF SETTLER (THOS. SQ. FT.)
              VAR -  DESIGN OVERFLOW RATE (GPD/SQFT)
      ALUMFS: PARM - CHEMICAL USAGE (LBS AL/DAY)
              VAR -  COST OF  CHEMICAL ($/LB ALUM)
      FECLFS: PARM - CHEMICAL USAGE (LBS FE/DAY)
              VAR -  COST OF CHEMICAL ($/LB FECL3)
      LIMEFS: PARM - CHEMICAL USAGE (LBS CAO/DAY)
              VAR -  COST OF CHEMICAL ($/LB CAO)
      POLYFS: PARM - CHEMICAL USAGE (LBS/DAY)
              VAR -  COST OF CHEMICAL ($/LB POLY)
      CO2FS : PARM - CHEMICAL USAGE (LBS/DAY)
              VAR -  COST OF CHEMICAL ($/LB CO2)
      NAALFS: PARM - CHEMICAL USAGE (LBS AL/DAY)
              VAR -  COST OF CHEMICAL ($/LB NAAL)
      PCKLFS: PARM - CHEMICAL USAGE (LBS FE/DAY)
              VAR -  COST OF CHEMICAL ($/LB FECL2)
      NAOHFS: PARM - CHEMICAL USAGE (LBS/DAY)
              VAR -  COST OF CHEMICAL ($/LB NAOH)
      RECALC: PARM - MAXIMUM CAPACTIY (MGD)
      FLOCCT: PARM - MAXIMUM CAPACITY (MGD)
   MAXP  - MAXIMUM NUMBER OF PROCESSES

AUTHOR:
   RON ORNER     10 OCT 72


COMMON BLOCK:
   TRTCST

PURPOSE:
   TREATMENT COSTS FOR 45 PROCESSES OVER 20 TIME PERIODS

VARIABLES:
   OMHRS  - OPERATING MAN-HOURS
   MMHRS  - MAINTAINENCE MAN-HOURS
   TMS    - TOTAL MATERIAL AND SUPPLY COST
   CONCOS - CONSTRUCTION COST
   AMCOST - AMORTIZED CONSTRUCTION COST FROM TIME PERIOD
                                 TPFADD TO MAXTP
   TPFADD - TIME PERIOD WHEN FIRST ADDITIONAL AMOUNT OF
                                 EQUIPMENT IS NEEDED
AUTHOR:
   RON ORNER     10 OCT 72
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```
COMMON BLOCK:
   TSCST

PURPOSE:
   TIME AND LOCATION DIFFERENCE COSTS - MULTIPLIERS TO CONVERT
   TO PRESENT LOCAL $

VARIABLES:
   CNSTRC - (WQO-STP INDEX)/100.
   MATRLS - MATERIAL COST MULTIPLIER

AUTHOR:
   RON ORNER     10 OCT 72
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SECTION VII

CASE STUDIES

The primary purpose of the computer model is to assist local communities in evaluating the costs of various strategies undertaken to reduce effluent phosphorus. In order to demonstrate how the model can be used by a community we have performed three case studies which are presented in this section. Each case is designed with a different size community in mind. The cases include:

1. A community of approximately 50,000 population presently operating a 5 MGD secondary trickling filter treatment plant.

2. A medium size city of approximately 200,000 population operating a 20 MGD secondary activated sludge treatment plant.

3. A large city of approximately 500,000 population operating a 50 MGD primary treatment plant.

In each case we have assumed that the average per capita generation of liquid waste is 100 gallons per day and that peak flow is 80% of the average. It is also assumed that sludge disposal facilities of sufficient capacity to handle all sludge generated during a 20 year assumed time horizon are available within a distance of 5 miles from the treatment plant. Although we have not done so in these cases, it is possible to limit and disperse sludge disposal facilities if desired.

The treatment plants in each community had available the following process equipments adequately sized to treat the present influent load assuming that phosphorus removal was not required:

1. Raw waste pumping
2. Pre-treatment facilities
3. Primary settler
4. Primary sludge pumping
5. Chlorination
6. Gravity thickener
7. Sludge holding tank
8. Vacuum filter

In addition to the above, the trickling filter plant had a secondary settler, and recirculation pumping. The activated sludge plant had an aeration basin, mechanical aeration, secondary settler, and recirculation pumping.

Each case study was examined over a 20 year time horizon. In these case studies we assumed that the populations were constant over the

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time horizon. However, the program can accept linear, exponential, and piece-wise linear growth predictions. Cost estimates were generated (and appear in Tables 11, 12 and 13 for each case) for six different combinations of events. These combinations can be viewed as "strategies". Costs of achieving phosphorus effluent concentrations of both 2.0 mg/l and 0.5 mg/l were examined. For each of these effluent requirements the effect of federal and state governments financing 80% of the construction costs was examined as was the additional effect of restricting phosphate detergents. The detergent restriction evaluated in these cases consisted of a total ban on the use of phosphates in detergents assuming a national detergent consumption of 16 lbs/capita/year. The model can also accept various percentage decreases in phosphate consumption assuming a zero ban is not feasible.

It was also assumed that there would be no enforcement cost to the consumer since detergent manufacturers have recently complied with most phosphate restrictions and are anticipating further reductions in the future.

Case 1 - 5 MGD Trickling Filter Plant

For this case we found that a phosphorus effluent level of 2.0 mg/l can be achieved at a minimum cost of 4.6 cents/1000 gallons using a treatment scheme of alum added after the trickling filter. This is shown as scheme 15 in Table 11. (See Table 14 for a list of treatment schemes). The minimum cost was achieved assuming that all phosphate detergents would be banned and the federal and state governments would finance 80% of the required construction costs. As can be seen from Table 11, this scheme would also be the most cost effective if there were no ban on detergent phosphates and government financing was not available.

We can also see from Table 11that reducing the effluent phosphorus from 2.0 to 0.5 mg/l resulted in a different treatment scheme being selected. In this case scheme 17 also included the addition of alum after the trickling filter but, in addition, required that a multi-media filter be added to the alum treatment process.

The costs of the feasible treatment schemes capable of achieving 2.0 and 0.5 mg/l phosphorus effluent requirements are shown in Table 11. The long printouts for schemes 15 and 17, showing in detail the equipment and operating costs for the individual processes, are shown in Figures 18 and 19. The information shown in these tables and figures is available to the program user as part of the computer output format.

Case 2 - 20 MGD Activated Sludge Plant

For this case we found that the minimum cost of achieving a 2.0 mg/l phosphorus effluent was 4.0 cents/1000 gallons achieved with the

Table 11

5 MGD TRICKLING FILTER PLANT
TREATMENT COSTS IN CENTS/1000 GAL.

P	2	2	2	0.5	0.5	0.5
GOVFF		.8	.8		.8	.8
RESTRICT			yes			yes
SCHNO						
1	13.9	11.9	8.4			
2	10.0	8.4	6.6			
3	17.8	15.0	13.7			
4	13.1	10.9	11.7			
5	14.8	12.3	8.8			
6	11.0	8.8	7.0			
7	18.8	15.3	14.0			
8	14.0	11.2	12.1			
9	12.3	10.6	7.5			
10	10.0	8.4	6.3			
11	15.1	13.5	8.8			
12				18.9	14.3	10.2
13				16.6	12.1	9.1
14				21.7	17.1	11.5
15	7.7	6.7	4.6			
16	8.2	7.3	4.8			
17				13.7	10.0	7.3
18				14.9	11.2	7.7
21				15.3	10.3	11.2

NOTES:
1. P = Phosphorus effluent level in mg/l.
2. GOVFF = Fraction of construction cost financed by federal and state governments.
3. RESTRICT = Restrictions on phosphate detergents.
4. SCHNO = Treatment scheme number.
5. ___ = Lowest treatment cost.

Figure 18

5 MGD Trickling Filter Plant

```
                              CASE  1

LIQUID TREATMENT SCHEME =     15
AMORTIZATION RATE =0.05 AMORTIZATION LIFETIME =20.0
FRACTION OF CONSTRUCTION COST FINANCED BY GOVERNMENT   = .0

PROCESS NAME    CONSTRUCTION        SIZING
                COST(1000 $ )      PARAMETER            AMORTIZED COST    YEAR PROCESS
                                                         (1000 $ /TP)     FIRST NEEDED
RAW WSTE PMP        0.0             0.0   MGD                0.0             1994.0
PRE TRETMENT        0.0             0.0   MGD                0.0             1994.0
PRIM SETTLER        0.0             0.0   TSF                0.0             1994.0
PRMYSLGE PMP        0.0             0.0   GPM                0.0             1994.0
TRKLNG FILTR        0.0             0.0   TCF                0.0             1994.0
SECY SETTLER        0.0             0.0   TSF                0.0             1994.0
RECIRC PMPNG        0.0             0.0   MGD                0.0             1994.0
CHLORNE FEED        0.0             0.0   #/D                0.0             1994.0
CHLORNE BASN        0.0             0.0   TCF                0.0             1994.0
GRAV THICKNR       34.824           0.022 TSF                0.0             1994.0
SLGE HLD TNK       15.649           0.987 TCF                2.794           1974.0
VACUUM FILTR      104.751          39.600 SQFT               1.256           1974.0
ALUM FEEDING       49.858         624.750 #/D                8.406           1974.0
FECL FEEDING       45.525          64.565 #/D                4.001           1974.0
LIME FEEDING       15.901         746.367 #/D                3.653           1974.0
                                                             1.276           1974.0
TOTALS =          266.507
                                                            21.385
```

Figure 18 (cont.)

```
                                   PERIODIC OPERATING COSTS

PROCESS NAME      OPERATING MAN-HOURS          MAINTAINANCE MAN-HOURS
                    (MAN-HOURS/TP)                 (MAN-HOURS/TP)
                 AVE.      MAX.      MIN.      AVE.      MAX.      MIN.

RAW WSTE PMP       0.        0.        0.        0.        0.        0.
PRE TRETMENT       0.        0.        0.        0.        0.        0.
PRIM SETTLER       0.        0.        0.        0.        0.        0.
PRMYSLGE PMP       0.        0.        0.        0.        0.        0.
TRKLNG FILTR       0.        0.        0.        0.        0.        0.
SECY SETTLER       0.        0.        0.        0.        0.        0.
RECIRC PMPNG       0.        0.        0.        0.        0.        0.
CHLORNE FEED       0.        0.        0.        0.        0.        0.
CHLORNE BASN       0.        0.        0.        0.        0.        0.
GRAV THICKNR       2.        2.        2.        1.        1.        1.
SLGE HLD TNK      18.       18.       18.       11.       11.       11.
VACUUM FILTR     665.      665.      665.       80.       80.       80.
ALUM FEEDING       0.        0.        0.     1473.     1473.     1473.
FECL FEEDING       0.        0.        0.      600.      600.      600.
LIME FEEDING       0.        0.        0.     1578.     1578.     1578.

TOTALS =         685.      685.      685.     3742.     3742.     3742.
```

Figure 18 (cont.)

```
                         PERIODIC OPERATING COSTS

                   MATERIAL & SUPPLY COST            LABOR COST    TOTAL O&M
PROCESS NAME             ( $ /TP)                    (AVERAGE)    (1000$/TP)
                  AVE.        MAX.          MIN.    (1000$/TP)

RAW WSTE PMP      0.0          0.0           0.0         0.0           0.0
PRE TRETMENT      0.0          0.0           0.0         0.0           0.0
PRIM SETTLER      0.0          0.0           0.0         0.0           0.0
PRMYSLGE PMP      0.0          0.0           0.0         0.0           0.0
TRKLNG FILTR      0.0          0.0           0.0         0.0           0.0
SECY SETTLER      0.0          0.0           0.0         0.0           0.0
RECIRC PMPNG      0.0          0.0           0.0         0.0           0.0
CHLORNE FEED      0.0          0.0           0.0         0.0           0.0
CHLORNE BASN      0.0          0.0           0.0         0.0           0.0
GRAV THICKNR      5.67         5.67          5.67        0.010         0.015
SLGE HLD TNK     54.57        54.57         54.57        0.133         0.187
VACUUM FLITR   3166.75      3166.75       3166.75        3.382         6.549
ALUM FEEDING  78872.44     78872.69      78872.69        6.693        85.565
FECL FEEDING   2998.12      2998.12       2998.12        2.725         5.724
LIME FEEDING   2855.35      2855.35       2855.35        7.167        10.022

TOTALS =      87952.75     87953.00      87953.00       20.109       108.062
```

Figure 18 (cont.)

```
                    UNIT COST DATA
                 (CENTS/1000 GALLONS)

PROCESS NAME   AMORTIZATION   LABOR   MATERIAL & SUPPLY   TOTAL

RAW WSTE PMP       0.0         0.0          0.0            0.0
PRE TRETMENT       0.0         0.0          0.0            0.0
PRIM SETTLER       0.0         0.0          0.0            0.0
PRMYSLGE PMP       0.0         0.0          0.0            0.0
TRKLNG FILTR       0.0         0.0          0.0            0.0
SECY SETTLER       0.0         0.0          0.0            0.0
RECIRC PMPNG       0.0         0.0          0.0            0.0
CHLORNE FEED       0.0         0.0          0.0            0.0
CHLORNE BASN       0.0         0.0          0.0            0.0
GRAV THICKNR       0.15        0.00         0.00           0.15
SLGE HLD TNK       0.07        0.01         0.00           0.08
VACUUM FILTR       0.46        0.19         0.17           0.82
ALUM FEEDING       0.22        0.37         4.32           4.91
FECL FEEDING       0.20        0.15         0.16           0.51
LIME FEEDING       0.07        0.39         0.16           0.62

TOTALS =           1.17        1.10         4.82           7.09

                  SOLID SINKS COSTS

TIME     SINK   AMOUNT SOLIDS        COST
PERIOD   USED      (TONS)           ($/TP)
   1       1          410.46       10261.50
   2       1          410.46       10261.50
   3       1          410.46       10261.50
   4       1          410.46       10261.50
   5       1          410.46       10261.50
   6       1          410.46       10261.50
   7       1          410.46       10261.50
   8       1          410.46       10261.50
   9       1          410.46       10261.50
  10       1          410.46       10261.50
  11       1          410.46       10261.50
  12       1          410.46       10261.50
  13       1          410.46       10261.50
  14       1          410.46       10261.50
  15       1          410.46       10261.50
  16       1          410.46       10261.50
  17       1          410.46       10261.50
  18       1          410.46       10261.50
  19       1          410.46       10261.50
  20       1          410.46       10261.50

  TOTALS =               8209.17      205229.12

UNIT COSTS FOR SOLID WASTE DISPOSAL (CENTS/1000  GAL.) = 0.56
TOTAL UNIT COST (CENTS/1000 GAL) = 7.66
```

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Figure 19

5 MGD Trickling Filter Plant

```
                              CASE  1


LIQUID TREATMENT SCHEME =    17
AMORTIZATION RATE =0.05 AMORTIZATION LIFETIME =20.0
FRACTION OF CONSTRUCTION COST FINANCED BY GOVERNMENT  = .0

PROCESS NAME    CONSTRUCTION        SIZING                AMORTIZED COST      YEAR PROCESS
               COST(1000 $ )       PARAMETER                (1000 $ /TP)      FIRST NEEDED

RAW WSTE PMP        0.0              0.0     MGD               0.0              1994.0
PRE TRETMENT        0.0              0.0     MGD               0.0              1994.0
PRIM SETTLER        0.0              0.0     TSF               0.0              1994.0
PRMYSLGE PMP        0.0              0.0     GPM               0.0              1994.0
TRKLNG FILTR        0.0              0.0     TCF               0.0              1994.0
SECY SETTLER        0.0              0.0     TSF               0.0              1994.0
RECIRC PMPNG        0.0              0.0     MGD               0.0              1994.0
CHLORNE FEED        0.0              0.0     #/D               0.0              1994.0
CHLORNE BASN        0.0              0.0     TCF               0.0              1994.0
MUL-MED FLTR      595.028            5.000   MGD              47.747            1974.0
RECIRC PMPNG      124.588            9.000   MGD               9.997            1974.0
GRAV THICKNR       30.645            0.205   TSF               2.459            1974.0
SLGE HLD TNK       27.753            3.193   TCF               2.227            1974.0
VACUUM FILTR      157.691           88.687   SQFT             12.654            1974.0
ALUM FEEDING       49.858          624.750   #/D               4.001            1974.0
FECL FEEDING       45.525           83.588   #/D               3.653            1974.0
LIME FEEDING       18.908          966.279   #/D               1.517            1974.0

TOTALS =         1049.994                                     84.255
```

Figure 19 (cont.)

PERIODIC OPERATING COSTS

PROCESS NAME	OPERATING MAN-HOURS (MAN-HOURS/TP)			MAINTAINANCE MAN-HOURS (MAN-HOURS/TP)		
	AVE.	MAX.	MIN.	AVE.	MAX.	MIN.
RAW WSTE PMP	0.	0.	0.	0.	0.	0.
PRE TRETMENT	0.	0.	0.	0.	0.	0.
PRIM SETTLER	0.	0.	0.	0.	0.	0.
PRMYSLGE PMP	0.	0.	0.	0.	0.	0.
TRKLNG FILTR	0.	0.	0.	0.	0.	0.
SECY SETTLER	0.	0.	0.	0.	0.	0.
RECIRC PMPNG	0.	0.	0.	0.	0.	0.
CHLORNE FEED	0.	0.	0.	0.	0.	0.
CHLORNE BASN	0.	0.	0.	0.	0.	0.
MUL-MED FLTR	1672.	1672.	1672.	0.	0.	0.
RECIRC PMPNG	597.	597.	597.	519.	519.	519.
GRAV THICKNR	16.	16.	16.	7.	7.	7.
SLGE HLD TNK	57.	57.	57.	33.	33.	33.
VACUUM FILTR	1428.	1428.	1428.	171.	171.	171.
ALUM FEEDING	0.	0.	0.	1473.	1473.	1473.
FECL FEEDING	0.	0.	0.	600.	600.	600.
LIME FEEDING	0.	0.	0.	1660.	1660.	1660.
TOTALS =	3769.	3769.	3769.	4464.	4464.	4464.

Figure 19 (cont.)

```
                          PERIODIC OPERATING COSTS

PROCESS NAME    MATERIAL & SUPPLY COST              LABOR COST   TOTAL O&M
                      ( $ /TP)                      (AVERAGE)    (1000$/TP)
                  AVE.        MAX.          MIN.    (1000$/TP)

RAW WSTE PMP      0.0         0.0           0.0        0.0          0.0
PRE TRETMENT      0.0         0.0           0.0        0.0          0.0
PRIM SETTLER      0.0         0.0           0.0        0.0          0.0
PRMYSLGE PMP      0.0         0.0           0.0        0.0          0.0
TRKLNG FILTR      0.0         0.0           0.0        0.0          0.0
SEC SETTLER       0.0         0.0           0.0        0.0          0.0
RECIRC PMPNG      0.0         0.0           0.0        0.0          0.0
CHLORNE FEED      0.0         0.0           0.0        0.0          0.0
CHLORNE BASN      0.0         0.0           0.0        0.0          0.0
MUL_MED FLTR   8013.89     8013.92       8013.92       7.594       15.608
RECIRC PMPNG   4312.23     4312.24       4312.24       5.072        9.384
GRAV THICKNR     51.20       51.20         51.20       0.105        0.156
SLGE HLD TNK    171.56      171.56        171.56       0.410        0.582
VACUUM FLITR   6882.15     6882.18       6882.18       7.262       14.144
ALUM FEEDING  78872.44    78872.69      78872.69       6.693       85.565
FECL FEEDING   3881.48     3881.49       3881.49       2.725        6.607
LIME FEEDING   3696.66     3696.66       3696.66       7.541       11.238

TOTALS =     105881.50   105881.81     105881.81      37.402      143.283
```

Figure 19 (cont.)

```
                         UNIT COST DATA
                       (CENTS/1000 GALLONS)

PROCESS NAME    AMORTIZATION     LABOR    MATERIAL & SUPPLY     TOTAL

RAW WSTE PMP    0.0              0.0           0.0               0.0
PRE TRETMENT    0.0              0.0           0.0               0.0
PRIM SETTLER    0.0              0.0           0.0               0.0
PRMYSLGE PMP    0.0              0.0           0.0               0.0
TRKLNG FILTR    0.0              0.0           0.0               0.0
SECY SETTLER    0.0              0.0           0.0               0.0
RECIRC PMPNG    0.0              0.0           0.0               0.0
CHLORNE FEED    0.0              0.0           0.0               0.0
CHLORNE BASN    0.0              0.0           0.0               0.0
MUL-MED FLTR    2.62             0.42          0.44              3.47
RECIRC PMPNG    0.55             0.28          0.24              1.06
GRAV THICKNR    0.13             0.01          0.00              0.14
SLGE HLD TNK    0.12             0.02          0.01              0.15
VACUUM FILTR    0.69             0.40          0.38              1.47
ALUM FEEDING    0.22             0.37          4.32              4.91
FECL FEEDING    0.20             0.15          0.21              0.56
LIME FEEDING    0.08             0.41          0.20              0.70

TOTALS =        4.62             2.05          5.80             12.47
                        SOLID SINKS COSTS

TIME      SINK    AMOUNT SOLIDS         COST
PERIOD    USED       (TONS)            ($/TP)
     1     1          912.13         22803.34
     2     1          912.13         22803.34
     3     1          912.13         22803.34
     4     1          912.13         22803.34
     5     1          912.13         22803.34
     6     1          912.13         22803.34
     7     1          912.13         22803.34
     8     1          912.13         22803.34
     9     1          912.13         22803.34
    10     1          912.13         22803.34
    11     1          912.13         22803.34
    12     1          912.13         22803.34
    13     1          912.13         22803.34
    14     1          912.13         22803.34
    15     1          912.13         22803.34
    16     1          912.13         22803.34
    17     1          912.13         22803.34
    18     1          912.13         22803.34
    19     1          912.13         22803.34
    20     1          912.13         22803.34

  TOTALS =           18242.66        456066.31

UNIT COSTS FOR SOLID WASTE DISPOSAL (CENTS/1000  GAL.) = 1.25
TOTAL UNIT COST (CENTS/1000 GAL) =13.72
```

addition of ferric chloride to the aeration basin. This is shown as scheme 10 in Table 12. This scheme is also the least cost treatment method when government financing is available and there is no limitation on detergent phosphates.

When an effluent phosphorus concentration of no more than 0.5 mg/l was required, the best treatment scheme was the addition of a multi-media filter to the ferric chloride process. This scheme is number 13 in Table 12.

When there is no detergent phosphate limitation the best scheme became the single stage tertiary lime process shown as number 21. This scheme also remained the best choice if there was no government financing. This fact resulted from a balancing of two effects. The capital costs for the tertiary lime process were a larger fraction of the total costs than was the case for the ferric chloride process. This resulted in a greater increase for the lime process when government financing was reduced. However, the sludge disposal costs for the ferric chloride process were 0.9 cents/1000 gallons while they were essentially zero for the lime process since the lime sludge was recalcined and thus reused.

There was an additional consideration in this case due to chemical costs. The cost of new lime was less than 0.5 cents/1000 gallons while the cost of ferric chloride was on the order of 4. cents/1000 gallon. Although much more lime is used than ferric chloride, the ferric chloride was not recalcined and the overall chemical cost was always greater than the lime.

The long printouts of the lower cost treatment schemes including schemes 10, 13, and 21 are presented in Figures 20, 21, and 22.

Case 3 - 50 MGD Primary Plant

In this case it was assumed that the treatment plant would require upgrading to secondary treatment and that the costs of this upgrading would be included in the phosphorus removal cost.

In this case we evaluated the two options of either upgrading with a trickling filter or an activated sludge process. For the case of a total phosphate ban and 80% government financing the least cost scheme was the addition of alum after a trickling filter. This scheme is shown as number 15 in Table 13. When no government financing was available and the phosphate ban was lifted, the addition of alum after the aeration basin of an activated sludge plant became equivalent in cost to the alum-trickling filter scheme.

When the effluent limit was reduced to 0.5 mg/l, scheme 17 which is the addition of a multi-media filter after alum addition to the trickling filter effluent, was the lowest cost scheme. With no phosphate

Table 12

20 MGD ACTIVATED SLUDGE PLANT
TREATMENT COSTS IN CENTS/1000 GAL.

P	2	2	2	0.5	0.5	0.5
GOVFF		.8	.8		.8	.8
RESTRICT			yes			yes
SCHNO						
1	11.1	9.9	6.4			
2	7.6	6.5	4.8			
3	16.5	13.9	12.7			
4	9.8	8.6	9.5			
5	11.7	10.1	6.7			
6	8.1	6.7	5.1			
7	17.1	14.2	12.9			
8	10.4	8.9	9.7			
9	8.3	8.0	5.0			
10	6.2	5.9	4.0			
11	11.2	11.0	6.4			
12				13.4	10.9	7.0
13				11.3	8.8	6.0
14				16.3	13.8	8.4
15	7.9	6.4	4.4			
16	8.4	7.0	4.7			
17				12.3	8.9	6.3
18				13.6	10.0	6.8
21				9.4	6.2	7.1

NOTES:

1. P = Phosphorus effluent level in mg/l.
2. GOVFF = Fraction of construction cost financed by federal and state governments.
3. RESTRICT = Restrictions on phosphate detergents.
4. SCHNO = Treatment scheme number.
5. ___ = Lowest treatment cost.

Figure 20
20 MGD Activated Sludge Plant

```
                         CASE  2

LIQUID TREATMENT SCHEME =     10
AMORTIZATION RATE =0.05 AMORTIZATION LIFETIME =20.0
FRACTION OF CONSTRUCTION COST FINANCED BY GOVERNMENT  = .0

PROCESS NAME    CONSTRUCTION        SIZING              AMORTIZED COST      YEAR PROCESS
                COST(1000 $ )      PARAMETER             (1000 $ /TP)       FIRST NEEDED

RAW WSTE PMP         0.0              0.0    MGD             0.0               1994.0
PRE TRETMENT         0.0              0.0    MGD             0.0               1994.0
PRIM SETTLER         0.0              0.0    TSF             0.0               1994.0
PRMYSLGE PMP         0.0              0.0    GPM             0.0               1994.0
AERTN BASIN          0.0              0.0    TCF             0.0               1994.0
MECH AERATN          0.0              0.0     HP             0.0               1994.0
SECY SETTLER         0.0              0.0    TSF             0.0               1994.0
RECIRC PMPNG         0.0              0.0    MGD             0.0               1994.0
CHLORNE FEED         0.0              0.0    #/D             0.0               1994.0
CHLORNE BASN         0.0              0.0    TCF             0.0               1994.0
GRAV THICKNR        38.163            0.546  TSF             3.062             1974.0
SLGE HLD TNK         0.0              0.0    TCF             0.0               1994.0
VACUUM FILTR        98.759           34.950  SQFT            7.925             1974.0
FECL FEEDING       115.133         6446.578  #/D             9.239             1974.0
LIME FEEDING        36.171         2541.481  #/D             2.903             1974.0

TOTALS =           288.226                                  23.128
```

Figure 20 (cont.)

```
                                      PERIODIC OPERATING COSTS
    PROCESS NAME         OPERATING MAN-HOURS      MAINTAINANCE MAN-HOURS
                           (MAN-HOURS/TP)             (MAN-HOURS/TP)
                         AVE.     MAX.     MIN.    AVE.     MAX.     MIN.

    RAW WSTE PMP           0.       0.       0.      0.       0.       0.
    PRE TRETMENT           0.       0.       0.      0.       0.       0.
    PRIM SETTLER           0.       0.       0.      0.       0.       0.
    PRMYSLGE PMP           0.       0.       0.      0.       0.       0.
    AERTN BASIN            0.       0.       0.      0.       0.       0.
    MECH AERATN            0.       0.       0.      0.       0.       0.
    SECY SETTLER           0.       0.       0.      0.       0.       0.
    RECIRC PMPNG           0.       0.       0.      0.       0.       0.
    CHLORNE FEED           0.       0.       0.      0.       0.       0.
    CHLORNE BASN           0.       0.       0.      0.       0.       0.
    GRAV THICKNR          41.      41.      41.     23.      23.      23.
    SLGE HLD TNK           0.       0.       0.      0.       0.       0.
    VACUUM FILTR        3013.    3013.    3013.    369.     369.     369.
    FECL FEEDING           0.       0.       0.   2884.    2884.    2884.
    LIME FEEDING           0.       0.       0.   2009.    2009.    2009.

    TOTALS =            3055.    3055.    3055.   5284.    5284.    5284.
```

Figure 20 (cont.)

```
                       PERIODIC OPERATING COSTS

PROCESS NAME        MATERIAL % SUPPLY COST          LABOR COST    TOTAL O&M
                            ( $ /TP)                (AVERAGE)    (1000$/TP)
                     AVE.         MAX.         MIN.  (1000$/TP)

RAW WSTE PMP        0.0          0.0          0.0         0.0          0.0
PRE TRETMENT        0.0          0.0          0.0         0.0          0.0
PRIM SETTLER        0.0          0.0          0.0         0.0          0.0
PRMYSLGE PMP        0.0          0.0          0.0         0.0          0.0
AERTN BASIN         0.0          0.0          0.0         0.0          0.0
MECH AERATN         0.0          0.0          0.0         0.0          0.0
SECY SETTLER        0.0          0.0          0.0         0.0          0.0
RECIRC PMPNG        0.0          0.0          0.0         0.0          0.0
CHLORNE FEED        0.0          0.0          0.0         0.0          0.0
CHLORNE BASN        0.0          0.0          0.0         0.0          0.0
GRAV THICKNR       88.40        88.40        88.40        0.290        0.378
SLGE HLD TNK        0.0          0.0          0.0         0.0          0.0
VACUUM FLITR    17365.26     17365.30     17365.30       15.364       32.729
FECL FEEDING   299353.00    299353.06    299353.06       13.101      312.453
LIME FEEDING     9722.82      9722.85      9722.85        9.124       18.847

TOTALS =       326529.44    326529.56    326529.56       37.878      364.407
```

Figure 20 (cont.)

```
                         UNIT COST DATA
                       (CENTS/1000 GALLONS)

PROCESS NAME   AMORTIZATION   LABOR   MATERIAL & SUPPLY   TOTAL

RAW WSTE PMP       0.0         0.0          0.0            0.0
PRE TRETMENT       0.0         0.0          0.0            0.0
PRIM SETTLER       0.0         0.0          0.0            0.0
PRMYSLGE PMP       0.0         0.0          0.0            0.0
AERTN BASIN        0.0         0.0          0.0            0.0
MECH AERATN        0.0         0.0          0.0            0.0
SECY SETTLER       0.0         0.0          0.0            0.0
RECIRC PMPNG       0.0         0.0          0.0            0.0
CHLORNE FEED       0.0         0.0          0.0            0.0
CHLORNE BASN       0.0         0.0          0.0            0.05
GRAV THICKNR       0.04        0.00         0.00           0.0
SLGE HLD TNK       0.0         0.0          0.0            0.56
VACUUM FILTR       0.11        0.21         0.24           4.41
FECL FEEDING       0.13        0.18         4.10           0.30
LIME FEEDING       8.04        0.12         0.13

TOTALS =           0.32        0.52         4.47           5.31
                         SOLID SINKS COSTS

TIME      SINK    AMOUNT SOLIDS        COST
PERIOD    USED       (TONS)           ($/TP)
     1       1         2553.97      63849.36
     2       1         2553.97      63849.36
     3       1         2553.97      63849.36
     4       1         2553.97      63849.36
     5       1         2553.97      63849.36
     6       1         2553.97      63849.36
     7       1         2553.97      63849.36
     8       1         2553.97      63849.36
     9       1         2553.97      63849.36
    10       1         2553.97      63849.36
    11       1         2553.97      63849.36
    12       1         2553.97      63849.36
    13       1         2553.97      63849.36
    14       1         2553.97      63849.36
    15       1         2553.97      63849.36
    16       1         2553.97      63849.36
    17       1         2553.97      63849.36
    18       1         2553.97      63849.36
    19       1         2553.97      63849.36
    20       1         2553.97      63849.36

  TOTALS =            51079.45    1276985.00

 UNIT COSTS FOR SOLID WASTE DISPOSAL (CENTS/1000  GAL.) = 0.87
 TOTAL UNIT COST (CENTS/1000 GAL) = 6.18
```

Figure 21

20 MGD Activated Sludge Plant

```
                    CASE  2


LIQUID TREATMENT SCHEME =     13
AMORTIZATION RATE =0.05 AMORTIZATION LIFETIME =20.0
FRACTION OF CONSTRUCTION COST FINANCED BY GOVERNMENT  = .0

PROCESS NAME     CONSTRUCTION          SIZING                 AMORTIZED COST       YEAR PROCESS
                 COST(1000 $ )        PARAMETER                (1000 $ /TP)        FIRST NEEDED

RAW WSTE PMP         0.0                0.0    MGD                  0.0               1994.0
PRE TRETMENT         0.0                0.0    MGD                  0.0               1994.0
PRIM SETTLER         0.0                0.0    TSF                  0.0               1994.0
PRMYSLGE PMP         0.0                0.0    GPM                  0.0               1994.0
AERTN BASIN          0.0                0.0    TCF                  0.0               1994.0
MECH AERATN          0.0                0.0     HP                  0.0               1994.0
SECY SETTLER         0.0                0.0    TSF                  0.0               1994.0
RECIRC PMPNG         0.0                0.0    MGD                  0.0               1994.0
CHLORNE FEED         0.0                0.0    #/D                  0.0               1994.0
CHLORNE BASN         0.0                0.0    TCF                  0.0               1994.0
MUL-MED FLTR      1870.254             20.000  MGD                150.075             1974.0
RECIRC PMPNG       372.327             38.000  MGD                 29.877             1974.0
GRAV THICKNR        59.732              1.712  TSF                  4.793             1974.0
SLGE HLD TNK        53.183             11.450  TCF                  4.268             1974.0
VACUUM FILTR       339.398            326.500  SQFT                27.234             1974.0
FECL FEEDING       118.005           6616.062  #/D                  9.469             1974.0
LIME FEEDING        42.581           3241.200  #/D                  3.417             1974.0

TOTALS =          2855.480                                        229.133
```

Figure 21 (cont.)

```
                              PERIODIC OPERATING COSTS

 PROCESS NAME     OPERATING MAN-HOURS        MAINTAINANCE MAN-HOURS
                   (MAN-HOURS/TP)               (MAN-HOURS/TP)
                 AVE.      MAX.      MIN.      AVE.      MAX.      MIN.

 RAW WSTE PMP      0.        0.        0.        0.        0.        0.
 PRE TRETMENT      0.        0.        0.        0.        0.        0.
 PRIM SETTLER      0.        0.        0.        0.        0.        0.
 PRMYSLGE PMP      0.        0.        0.        0.        0.        0.
 AERTN BASIN       0.        0.        0.        0.        0.        0.
 MECH AERATN       0.        0.        0.        0.        0.        0.
 SECY SETTLER      0.        0.        0.        0.        0.        0.
 RECIRC PMPNG      0.        0.        0.        0.        0.        0.
 CHLORNE FEED      0.        0.        0.        0.        0.        0.
 CHLORNE BASN      0.        0.        0.        0.        0.        0.
 MUL-MED FLTR   3772.     3772.     3772.        0.        0.        0.
 RECIRC PMPNG   1153.     1153.     1153.      971.      971.      971.
 GRAV THICKNR    126.      126.      126.       69.       69.       69.
 SLGE HLD TNK     95.       95.       95.       59.       59.       59.
 VACUUM FILTR   5927.     5927.     5927.      727.      727.      727.
 FECL FEEDING      0.        0.        0.     2927.     2927.     2927.
 LIME FEEDING      0.        0.        0.     2107.     2107.     2107.

 TOTALS =      11072.    11072.    11072.     6859.     6859.     6859.
```

Figure 21 (cont.)

```
                        PERIODIC OPERATING COSTS

PROCESS NAME      MATERIAL & SUPPLY COST              LABOR COST   TOTAL O&M
                        ( $ /TP)                      (AVERAGE)    (1000$/TP)
                  AVE.         MAX.          MIN.     (1000$/TP)

RAW WSTE PMP       0.0          0.0           0.0          0.0          0.0
PRE TRETMENT       0.0          0.0           0.0          0.0          0.0
PRIM SETTLER       0.0          0.0           0.0          0.0          0.0
PRMYSLGE PMP       0.0          0.0           0.0          0.0          0.0
AERTN BASIN        0.0          0.0           0.0          0.0          0.0
MECH AERATN        0.0          0.0           0.0          0.0          0.0
SECY SETTLER       0.0          0.0           0.0          0.0          0.0
RECIRC PMPNG       0.0          0.0           0.0          0.0          0.0
CHLORNE FEED       0.0          0.0           0.0          0.0          0.0
CHLORNE BASN       0.0          0.0           0.0          0.0          0.0
MUL-MED FLTR   26387.56     26387.59      26387.59        17.132       43.520
RECIRC PMPNG    8078.01      8078.03       8078.03         9.644       17.722
GRAV THICKNR     268.39       268.39        268.39         0.883        1.151
SLGE HLD TNK     402.13       402.13        402.13         0.700        1.102
VACUUM FLTER   34214.87     34214.87      34214.87        30.229       64.444
FECL FEEDING  307223.00    307223.06     307223.06        13.294      320.517
LIME FEEDING   12399.70     12399.75      12399.75         9.572       21.972

TOTALS =      388973.62    388973.75     388973.75        81.454      470.427
```

Figure 21 (cont.)

```
                             UNIT COST DATA
                           (CENTS/1000 GALLONS)

PROCESS NAME   AMORTIZATION   LABOR   MATERIAL & SUPPLY   TOTAL

RAW WSTE PMP       0.0         0.0          0.0            0.0
PRE TRETMENT       0.0         0.0          0.0            0.0
PRIM SETTLER       0.0         0.0          0.0            0.0
PRMYSLGE PMP       0.0         0.0          0.0            0.0
AERTN BASIN        0.0         0.0          0.0            0.0
MECH AERATN        0.0         0.0          0.0            0.0
SECY SETTLER       0.0         0.0          0.0            0.0
RECIRC PMPNG       0.0         0.0          0.0            0.0
CHLORNE FEED       0.0         0.0          0.0            0.0
CHLORNE BASN       0.0         0.0          0.0            0.0
MUL-MED FLTR       2.06        0.23         0.36           2.65
RECIRC PMPNG       0.41        0.13         0.11           0.65
GRAV THICKNR       0.07        0.01         0.00           0.08
SLGE HLD TNK       0.06        0.01         0.01           0.07
VACUUM FILTR       0.37        0.41         0.47           1.26
FECL FEEDING       0.13        0.18         4.21           4.52
LIME FEEDING       0.05        0.13         0.17           0.35

TOTALS =           3.14        1.12         5.33           9.58

                   SOLID SINKS COSTS
TIME      SINK   AMOUNT SOLIDS        COST
PERIOD    USED     (TONS)            ($/TP)
    1       1          5107.95    127698.69
    2       1          5107.95    127698.69
    3       1          5107.95    127698.69
    4       1          5107.95    127698.69
    5       1          5107.95    127698.69
    6       1          5107.95    127698.69
    7       1          5107.95    127698.69
    8       1          5107.95    127698.69
    9       1          5107.95    127698.69
   10       1          5107.95    127698.69
   11       1          5107.95    127698.69
   12       1          5107.95    127698.69
   13       1          5107.95    127698.69
   14       1          5107.95    127698.69
   15       1          5107.95    127698.69
   16       1          5107.95    127698.69
   17       1          5107.95    127698.69
   18       1          5107.95    127698.69
   19       1          5107.95    127698.69
   20       1          5107.95    127698.69

  TOTALS =           102158.87   2553966.00

 UNIT COSTS FOR SOLID WASTE DISPOSAL (CENTS/1000  GAL.) = 1.75
 TOTAL UNIT COST (CENTS/1000 GAL) =11.33
```

Figure 22. 20 MGD Activated Sludge Plant

```
                    CASE  2

LIQUID TREATMENT SCHEME =     21
AMORTIZATION RATE =0.05 AMORTIZATION LIFETIME =20.0
FRACTION OF CONSTRUCTION COST FINANCED BY GOVERNMENT  = .0

PROCESS NAME    CONSTRUCTION        SIZING          AMORTIZED COST     YEAR PROCESS
                COST(1000 $ )      PARAMETER         (1000 $ /TP)      FIRST NEEDED

RAW WSTE PMP          0.0             0.0   MGD            0.0           1994.0
PRE TRETMENT          0.0             0.0   MGD            0.0           1994.0
PRIM SETTLER          0.0             0.0   TSF            0.0           1994.0
PRMYSLGE PMP          0.0             0.0   GPM            0.0           1994.0
AERTN BASIN           0.0             0.0   TCF            0.0           1994.0
MECH AERATN           0.0             0.0    HP            0.0           1994.0
SECY SETTLER          0.0             0.0   TSF            0.0           1994.0
RECIRC PMPNG          0.0             0.0   MGD            0.0           1994.0
CHLORNE FEED          0.0             0.0   #/D            0.0           1994.0
CHLORNE BASN          0.0             0.0   TCF            0.0           1994.0
MUL-MED FLTR       1870.254          20.000 MGD          150.075         1974.0
RECIRC PMPNG        372.327          38.000 MGD           29.877         1974.0
GRAV THICKNR          0.0             0.0   TSF            0.0           1994.0
SLGE HLD TNK          0.0             0.0   TCF            0.0           1994.0
VACUUM FILTR          0.0             0.0   SQFT           0.0           1994.0
RECARBONATN1         85.288          55.704 TCF            6.844         1974.0
TER SETTLER1        374.382          28.571 TSF           30.042         1974.0
FECL FEEDING          0.0             0.0   #/D            0.0           1994.0
LIME FEEDING         82.873        8746.496 #/D            6.650         1974.0
CO2  FEEDING         27.699           0.190 #/D            2.223         1974.0
RECALCINATN         456.965          20.000               36.668         1974.0
FLOCC -TRTRY        355.555          20.000 MGD           28.531         1974.0

TOTALS =           3625.344                              290.909
```

Figure 22 (cont.)

```
                                          PERIODIC OPERATING COSTS
PROCESS NAME     OPERATING MAN-HOURS             MAINTAINANCE MAN-HOURS
                   (MAN-HOURS/TP)                   (MAN-HOURS/TP)
                  AVE.     MAX.     MIN.       AVE.     MAX.     MIN.

RAW WSTE PMP       0.       0.       0.         0.       0.       0.
PRE TRETMENT       0.       0.       0.         0.       0.       0.
PRIM SETTLER       0.       0.       0.         0.       0.       0.
PRMYSLGE PMP       0.       0.       0.         0.       0.       0.
AERTN BASIN        0.       0.       0.         0.       0.       0.
MECH AERATN        0.       0.       0.         0.       0.       0.
SECY SETTLER       0.       0.       0.         0.       0.       0.
RECIRC PMPNG       0.       0.       0.         0.       0.       0.
CHLORNE FEED       0.       0.       0.         0.       0.       0.
CHLORNE BASN       0.       0.       0.         0.       0.       0.
MUL-MED FLTR    3772.    3772.    3772.         0.       0.       0.
RECIRC PMPNG    1153.    1153.    1153.       971.     971.     971.
GRAV THICKNR       0.       0.       0.         0.       0.       0.
SLGE HLD TNK       0.       0.       0.         0.       0.       0.
VACUUM FILTR       0.      -0.      -0.         0.      -0.      -0.
RECARBONATN1       0.       0.       0.         0.       0.       0.
TER SETTLER1    1932.    1932.    1932.      1072.    1072.    1072.
FECL FEEDING       0.       0.       0.       600.     600.     600.
LIME FEEDING       0.       0.       0.      2563.    2563.    2563.
CO2  FEEDING     698.     698.     698.       590.     590.     590.
RECALCINATN     8625.    8625.    8625.      4380.    4380.    4380.
FLOCC -TRTRY       0.       0.       0.         0.       0.       0.

TOTALS =       16180.   16180.   16180.     10175.   10175.   10175.
```

Figure 22 (cont.)

```
                                       PERIODIC OPERATING COSTS
PROCESS NAME        MATERIAL & SUPPLY COST                 LABOR COST    TOTAL O&M
                           ( $ /TP)                        (AVERAGE)     (1000$/TP)
                   AVE.          MAX.          MIN.        (1000$/TP)

RAW WSTE PMP         0.0           0.0           0.0          0.0           0.0
PRE TRETMENT         0.0           0.0           0.0          0.0           0.0
PRIM SETTLER         0.0           0.0           0.0          0.0           0.0
PRMYSLGE PMP         0.0           0.0           0.0          0.0           0.0
AERTN BASIN          0.0           0.0           0.0          0.0           0.0
MECH AERATN          0.0           0.0           0.0          0.0           0.0
SECY SETTLER         0.0           0.0           0.0          0.0           0.0
RECIRC PMPNG         0.0           0.0           0.0          0.0           0.0
CHLORNE FEED         0.0           0.0           0.0          0.0           0.0
CHLORNE BASN         0.0           0.0           0.0          0.0           0.0
MUL-MED FLTR     26387.56      26387.59      26387.59        17.132        43.520
RECIRC PMPNG      8078.01       8078.03       8078.03         9.644        17.722
GRAV THICKNR         0.0           0.0           0.0          0.0           0.0
SLGE HLD TNK         0.0           0.0           0.0          0.0           0.0
VACUUM FILTR         0.0           0.0           0.0          0.0           0.0
RECARBONATN1         0.0           0.0           0.0          0.0           0.0
TER SETTLER1      3766.37       3766.38       3766.35        13.647        17.414
FECL FEEDING         0.0           0.0           0.0          2.725         2.725
LIME FEEDING     33461.12      33461.18      33461.18        11.640        45.102
CO2  FEEDING     70695.44      70695.62      70695.62         5.849        76.545
RECALCINATN     119493.12     119493.37     119493.37        59.076       178.569
FLOCC -TRTRY     11604.89      11604.92      11604.92         0.0          11.605

TOTALS =        273486.50     273487.00     273487.00       119.715       393.201
```

Figure 22 (cont.)

```
                     UNIT COST DATA
                   (CENTS/1000 GALLONS)

PROCESS NAME    AMORTIZATION    LABOR   MATERIAL & SUPPLY    TOTAL

RAW WSTE PMP       0.0          0.0          0.0              0.0
PRE TRETMENT       0.0          0.0          0.0              0.0
PRIM SETTLER       0.0          0.0          0.0              0.0
PRMYSLGE PMP       0.0          0.0          0.0              0.0
AERTN BASIN        0.0          0.0          0.0              0.0
MECH AERATN        0.0          0.0          0.0              0.0
SECY SETTLER       0.0          0.0          0.0              0.0
RECIRC PMPNG       0.0          0.0          0.0              0.0
CHLORNE FEED       0.0          0.0          0.0              0.0
CHLORNE BASN       0.0          0.0          0.0              0.0
MUL-MED FLTR       2.06         0.23         0.36             2.65
RECIRC PMPNG       0.41         0.13         0.11             0.65
GRAV THICKNR       0.0          0.0          0.0              0.0
SLGE HLD TNK       0.0          0.0          0.0              0.0
VACUUM FILTR       0.0          0.0          0.0              0.0
RECARBONATN1       0.09         0.0          0.0              0.09
TER SETTLER1       0.41         0.19         0.05             0.65
FECL FEEDING       0.0          0.04         0.0              0.04
LIME FEEDING       0.09         0.16         0.46             0.71
CO2  FEEDING       0.03         0.08         0.97             1.08
RECALCINATN        0.50         0.81         1.64             2.95
FLOCC -TRTRY       0.39         0.0          0.16             0.55

TOTALS =           3.99         1.64         3.75             9.37


                    SOLID SINKS COSTS

TIME       SINK    AMOUNT SOLIDS         COST
PERIOD     USED       (TONS)            ($/TP)

  TOTALS =                  0.0          0.0

UNIT COSTS FOR SOLID WASTE DISPOSAL (CENTS/1000  GAL.) =    0.0
TOTAL UNIT COST (CENTS/1000 GAL) = 9.37
```

detergent limitation, scheme 21 which is single stage tertiary lime, became the best choice.

The long printouts in these cases show the interesting relationship between capital costs, chemical costs, and operation of the plants. They are shown in Figures 23, 24, and 25.

Table 13

50 MGD PRIMARY PLANT
TREATMENT COSTS IN CENTS/1000 GAL.

P	2	2	2	0.5	0.5	0.5
GOVFF		.8	.8		.8	.8
RESTRICT			yes			yes
SCHNO						
1	13.0	10.8	7.4			
2	9.5	7.5	5.8			
3	18.2	14.8	13.5			
4	11.6	9.5	10.4			
5	13.3	11.0	7.6			
6	9.9	7.7	6.0			
7	18.6	14.9	13.7			
8	12.0	9.7	10.6			
9	10.6	9.1	6.2			
10	8.5	7.1	5.2			
11	13.5	12.1	7.6			
12				15.0	11.7	7.9
13				13.0	9.7	7.0
14				17.0	14.6	9.3
15	8.5	6.6	4.6			
16	9.1	7.2	4.9			
17				12.4	8.7	6.2
18				13.6	9.8	6.7
21				10.1	6.4	7.3

NOTES:
1. P = Phosphorus effluent level in mg/l.
2. GOVFF = Fraction of construction cost financed by federal and state governments.
3. RESTRICT = Restrictions on phosphate deterrents.
4. SCHNO = Treatment scheme number.
5. ___ = Lowest treatment cost.

Figure 23. 50 MGD Primary Plant

```
                    CASE  3

LIQUID TREATMENT SCHEME =     10
AMORTIZATION RATE =0.05 AMORTIZATION LIFETIME =20.0
FRACTION OF CONSTRUCTION COST FINANCED BY GOVERNMENT  = .0

PROCESS NAME    CONSTRUCTION       SIZING              AMORTIZED COST      YEAR PROCESS
                COST(1000 $ )     PARAMETER            (1000 $ /TP)        FIRST NEEDED

RAW WSTE PMP        0.0             0.0    MGD              0.0               1994.0
PRE TRETMENT        0.0             0.0    MGD              0.0               1994.0
PRIM SETTLER        0.0             0.0    TSF              0.0               1994.0
PRMYSLGE PMP        0.0             0.0    GPM              0.0               1994.0
AERTN BASIN      1674.708        1671.122  TCF            134.384             1974.0
MECH AERATN       378.948         694.166   HP             30.408             1974.0
SECY SETTLER      799.331          71.429  TSF             64.141             1974.0
RECIRC PMPNG      465.798          50.000  MGD             37.377             1974.0
CHLORNE FEED        0.0             0.0    #/D              0.0               1994.0
CHLORNE BASN        0.0             0.0    TCF              0.0               1994.0
GRAV THICKNR       52.480           1.289  TSF              4.211             1974.0
SLGE HLD TNK        0.0             0.0    TCF              0.0               1994.0
VACUUM FILTR      156.432          87.375  SQFT            12.553             1974.0
FECL FEEDING      336.751       16116.445  #/D             27.022             1974.0
LIME FEEDING       66.881        6353.695  #/D              5.367             1974.0

TOTALS =         3931.329                                 315.462
```

Figure 23 (cont.)

```
                         PERIODIC OPERATING COSTS

PROCESS NAME     OPERATING MAN-HOURS      MAINTAINANCE MAN-HOURS
                   (MAN-HOURS/TP)            (MAN-HOURS/TP)
                 AVE.     MAX.     MIN.     AVE.     MAX.     MIN.

RAW WSTE PMP       0.       0.       0.       0.       0.       0.
PRE TRETMENT       0.       0.       0.       0.       0.       0.
PRIM SETTLER       0.       0.       0.       0.       0.       0.
PRMYSLGE PMP       0.       0.       0.       0.       0.       0.
AERTN BASIN        0.       0.       0.       0.       0.       0.
MECH AERATN     3442.    3442.    3442.    2133.    2133.    2133.
SECY SETTLER    3481.    3481.    3481.    1949.    1949.    1949.
RECIRC PMPNG       0.       0.       0.    1133.    1133.    1133.
CHLORNE FEED       0.       0.       0.       0.       0.       0.
CHLORNE BASN       0.       0.       0.       0.       0.       0.
GRAV THICKNR      78.      78.      78.      43.      43.      43.
SLGE HLD TNK       0.       0.       0.       0.       0.       0.
VACUUM FILTR    6897.    6897.    6897.     862.     862.     862.
FECL FEEDING       0.       0.       0.    4996.    4996.    4996.
LIME FEEDING       0.       0.       0.    2406.    2406.    2406.

TOTALS =       13898.   13898.   13898.   13522.   13522.   13522.
```

Figure 23 (cont.)

```
                          PERIODIC OPERATING COSTS

PROCESS NAME        MATERIAL & SUPPLY COST              LABOR COST    TOTAL O&M
                           ( $ /TP)                     (AVERAGE)    (1000$/TP)
                    AVE.         MAX.           MIN.    (1000$/TP)

RAW WSTE PMP         0.0          0.0            0.0          0.0           0.0
PRE TRETMENT         0.0          0.0            0.0          0.0           0.0
PRIM SETTLER         0.0          0.0            0.0          0.0           0.0
PRMYSLGE PMP         0.0          0.0            0.0          0.0           0.0
AERTN BASIN          0.0          0.0            0.0          0.0           0.0
MECH AERATN    118122.00    118122.06      118122.06       25.325       143.447
SECY SETTLER     7493.70      7493.71        7493.71       24.665        32.159
RECIRC PMPNG    10396.82     10396.84       10396.84        5.149        15.546
CHLORNE FEED         0.0          0.0            0.0          0.0           0.0
CHLORNE BASN         0.0          0.0            0.0          0.0           0.0
GRAV THICKNR      166.05       166.05         166.05        0.548         0.714
SLGE HLD TNK         0.0          0.0            0.0          0.0           0.0
VACUUM FILTR    39537.44     39537.49       39537.49       35.242        74.779
FECL FEEDING   748382.00    748382.50      748382.50       22.696       771.078
LIME FEEDING    24307.07     24307.11       24307.11       10.930        35.237

TOTALS =       948405.00    948405.56      948405.56      124.555      1072.960
```

Figure 23 (cont.)

```
                           UNIT COST DATA
                        (CENTS/1000 GALLONS)

PROCESS NAME    AMORTIZATION    LABOR   MATERIAL & SUPPLY   TOTAL

RAW WSTE PMP        0.0          0.0          0.0            0.0
PRE TRETMENT        0.0          0.0          0.0            0.0
PRIM SETTLER        0.0          0.0          0.0            0.0
PRMYSLGE PMP        0.0          0.0          0.0            0.0
AERTN BASIN         0.74         0.0          0.0            0.74
MECH AERATN         0.17         0.14         0.65           0.95
SECY SETTLER        0.35         0.14         0.04           0.53
RECIRC PMPNG        0.20         0.03         0.06           0.29
CHLORNE FEED        0.0          0.0          0.0            0.0
CHLORNE BASN        0.0          0.0          0.0            0.0
GRAV THICKNR        0.02         0.00         0.00           0.03
SLGE HLD TNK        0.0          0.0          0.0            0.0
VACUUM FILTR        0.07         0.19         0.22           0.48
FECL FEEDING        0.15         0.12         4.10           4.37
LIME FEEDING        0.03         0.06         0.13           0.22

TOTALS =            1.73         0.68         5.20           7.61
                          SOLID SINKS COSTS

TIME      SINK    AMOUNT SOLIDS        COST
PERIOD    USED       (TONS)           ($/TP)
    1       1        6384.94       159623.50
    2       1        6384.94       159623.50
    3       1        6384.94       159623.50
    4       1        6384.94       159623.50
    5       1        6384.94       159623.50
    6       1        6384.94       159623.50
    7       1        6384.94       159623.50
    8       1        6384.94       159623.50
    9       1        6384.94       159623.50
   10       1        6384.94       159623.50
   11       1        6384.94       159623.50
   12       1        6384.94       159623.50
   13       1        6384.94       159623.50
   14       1        6384.94       159623.50
   15       1        6384.94       159623.50
   16       1        6384.94       159623.50
   17       1        6384.94       159623.50
   18       1        6384.94       159623.50
   19       1        6384.94       159623.50
   20       1        6384.94       159623.50

   TOTALS =        127698.75      3192463.00

 UNIT COSTS FOR SOLID WASTE DISPOSAL (CENTS/1000  GAL.) =  0.87
 TOTAL UNIT COST (CENTS/1000 GAL) = 8.48
```

Figure 24. 50 MGD Primary Plant

```
                                   CASE  3
LIQUID TREATMENT SCHEME =     15
AMORTIZATION RATE =0.05 AMORTIZATION LIFETIME =20.0
FRACTION OF CONSTRUCTION COST FINANCED BY GOVERNMENT  = .0

PROCESS NAME    CONSTRUCTION        SIZING                 AMORTIZED COST     YEAR PROCESS
               COST(1000 $ )      PARAMETER                (1000 $ /TP)      FIRST NEEDED

RAW WSTE PMP         0.0             0.0   MGD                    0.0             1994.0
PRE TRETMENT         0.0             0.0   MGD                    0.0             1994.0
PRIM SETTLER         0.0             0.0   TSF                    0.0             1994.0
PRMYSLGE PMP         0.0             0.0   GPM                    0.0             1994.0
TRKLNG FILTR      3659.099        2613.600 TCF                  293.618           1974.0
SECY SETTLER       799.331          71.429 TSF                   64.141           1974.0
RECIRC PMPNG       652.002          75.000 MGD                   52.319           1974.0
CHLORNE FEED         0.0             0.0   #/D                    0.0             1994.0
CHLORNE BASN         0.0             0.0   TCF                    0.0             1994.0
GRAV THICKNR         0.0             0.0   TSF                    0.0             1994.0
SLGE HLD TNK         0.0             0.0   TCF                    0.0             1994.0
VACUUM FILTR         0.0             0.0   SQFT                   0.0             1994.0
ALUM FEEDING       287.187        6247.492 #/D                   23.045           1974.0
FECL FEEDING        45.525         645.646 #/D                    3.653           1974.0
LIME FEEDING        74.509        7463.672 #/D                    5.979           1974.0

TOTALS =          5517.641                                      442.753
```

Figure 24 (cont.)

```
                              PERIODIC OPERATING COSTS

PROCESS NAME      OPERATING MAN-HOURS        MAINTAINANCE MAN-HOURS
                    (MAN-HOURS/TP)               (MAN-HOURS/TP)
                  AVE.     MAX.     MIN.     AVE.     MAX.     MIN.

RAW WSTE PMP        0.       0.       0.       0.       0.       0.
PRE TRETMENT        0.       0.       0.       0.       0.       0.
PRIM SETTLER        0.       0.       0.       0.       0.       0.
PRMYSLGE PMP        0.       0.       0.       0.       0.       0.
TRKLNG FILTR     3295.    3295.    3295.    1830.    1830.    1830.
SECY SETTLER     3481.    3481.    3481.    1949.    1949.    1949.
RECIRC PMPNG        0.       0.       0.    1456.    1456.    1456.
CHLORNE FEED        0.       0.       0.       0.       0.       0.
CHLORNE BASN        0.       0.       0.       0.       0.       0.
GRAV THICKNR        0.       0.       0.       0.       0.       0.
SLGE HLD TNK        0.       0.       0.       0.       0.       0.
VACUUM FILTR     4528.    4528.    4528.     562.     562.     562.
ALUM FEEDING        0.       0.       0.    5246.    5246.    5246.
FECL FEEDING        0.       0.       0.     969.     969.     969.
LIME FEEDING        0.       0.       0.    2484.    2484.    2484.

TOTALS =        11303.   11303.   11303.   14495.   14495.   14495.
```

Figure 24 (cont.)

```
                                            PERIODIC OPERATING COSTS
PROCESS NAME          MATERIAL & SUPPLY COST              LABOR COST   TOTAL O&M
                            ( $ /TP)                      (AVERAGE)    (1000$/TP)
                    AVE.         MAX.          MIN.      (1000$/TP)

RAW WSTE PMP         0.0          0.0           0.0          0.0          0.0
PRE TRETMENT         0.0          0.0           0.0          0.0          0.0
PRIM SETTLER         0.0          0.0           0.0          0.0          0.0
PRMYSLGE PMP         0.0          0.0           0.0          0.0          0.0
TRKLNG FILTR      2919.70      2919.70       2919.70       23.279       26.199
SECY SETTLER      7493.70      7493.71       7493.71       24.665       32.159
RECIRC FEED      10396.82     10396.84      10396.84        6.614       17.010
CHLORNE FEED         0.0          0.0           0.0          0.0          0.0
CHLORNE BASN         0.0          0.0           0.0          0.0          0.0
GRAV THICKNR         0.0          0.0           0.0          0.0          0.0
SLGE HLD TNK         0.0          0.0           0.0          0.0          0.0
VACUUM FILTR     23292.32     23292.36      23292.36       23.118       46.410
ALUM FEEDING    788727.00    788727.56     788727.56       23.829      812.556
FECL FEEDING     29981.19     29981.20      29981.20        4.402       34.383
LIME FEEDING     28553.50     28553.52      28553.52       11.282       39.836

TOTALS =        891364.19    891364.81     891364.81      117.188     1008.552
```

Figure 24 (cont.)

```
                          UNIT COST DATA
                        (CENTS/1000 GALLONS)

PROCESS NAME   AMORTIZATION   LABOR   MATERIAL & SUPPLY   TOTAL

RAW WSTE PMP       0.0         0.0           0.0           0.0
PRE TRETMENT       0.0         0.0           0.0           0.0
PRIM SETTLER       0.0         0.0           0.0           0.0
PRMYSLGE PMP       0.0         0.0           0.0           0.0
TRKLNG FILTR       1.61        0.13          0.02          1.75
SECY SETTLER       0.35        0.14          0.04          0.53
RECIRC PMPNG       0.29        0.04          0.06          0.38
CHLORNE FEED       0.0         0.0           0.0           0.0
CHLORNE BASN       0.0         0.0           0.0           0.0
GRAV THICKNR       0.0         0.0           0.0           0.0
SLGE HLD TNK       0.0         0.0           0.0           0.0
VACUUM FILTR       0.0         0.13          0.13          0.25
ALUM FEEDING       0.13        0.13          4.32          4.58
FECL FEEDING       0.02        0.02          0.16          0.21
LIME FEEDING       0.03        0.06          0.16          0.25

TOTALS =           2.43        0.64          4.88          7.95
                    SOLID SINKS COSTS

TIME      SINK   AMOUNT SOLIDS        COST
PERIOD    USED      (TONS)           ($/TP)
    1       1         4104.61     102615.12
    2       1         4104.61     102615.12
    3       1         4104.61     102615.12
    4       1         4104.61     102615.12
    5       1         4104.61     102615.12
    6       1         4104.61     102615.12
    7       1         4104.61     102615.12
    8       1         4104.61     102615.12
    9       1         4104.61     102615.12
   10       1         4104.61     102615.12
   11       1         4104.61     102615.12
   12       1         4104.61     102615.12
   13       1         4104.61     102615.12
   14       1         4104.61     102615.12
   15       1         4104.61     102615.12
   16       1         4104.61     102615.12
   17       1         4104.61     102615.12
   18       1         4104.61     102615.12
   19       1         4104.61     102615.12
   20       1         4104.61     102615.12

  TOTALS =           82091.94    2052301.00
 UNIT COSTS FOR SOLID WASTE DISPOSAL (CENTS/1000  GAL.) =  0.56
 TOTAL UNIT COST (CENTS/1000 GAL) = 8.51
```

Figure 25. 50 MGD Primary Plant

```
                     CASE  3

LIQUID TREATMENT SCHEME =     21
AMORTIZATION RATE =0.05 AMORTIZATION LIFETIME =20.0
FRACTION OF CONSTRUCTION COST FINANCED BY GOVERNMENT  = .0

PROCESS NAME    CONSTRUCTION         SIZING              AMORTIZED COST      YEAR PROCESS
                COST(1000 $ )      PARAMETER              (1000 $ /TP)       FIRST NEEDED

RAW WSTE PMP        0.0              0.0    MGD              0.0                1994.0
PRE TRETMENT        0.0              0.0    MGD              0.0                1994.0
PRIM SETTLER        0.0              0.0    TSF              0.0                1994.0
PRMYSLGE PMP        0.0              0.0    GPM              0.0                1994.0
AERTN BASIN      1674.708         1671.122  TCF            134.384              1974.0
MECH AERATN       378.948          694.166   HP             30.408              1974.0
SECY SETTLER      799.331           71.429  TSF             64.141              1974.0
RECIRC PMPNG      465.798           50.000  MGD             37.377              1974.0
CHLORNE FEED        0.0              0.0    #/D              0.0                1994.0
CHLORNE BASN        0.0              0.0    TCF              0.0                1994.0
MUL-MED FLTR     4115.578           50.000  MGD            330.247              1974.0
RECIRC PMPNG      759.593           90.000  MGD             60.952              1974.0
GRAV THICKNR        0.0              0.0    TSF              0.0                1994.0
SLGE HLD TNK        0.0              0.0    TCF              0.0                1994.0
VACUUM FILTR        0.0              0.0    SQFT             0.0                1994.0
RECARBONATN1      173.254          139.260  TCF             13.902              1974.0
TER SETTLER1      799.331           71.429  TSF             64.141              1974.0
FECL FEEDING        0.0              0.0    #/D              0.0                1994.0
LIME FEEDING      153.233        21866.230  #/D             12.296              1974.0
CO2  FEEDING       45.656            0.474  #/D              3.664              1974.0
RECALCINATN       522.194           50.000                  41.903              1974.0
FLOCC -TRTRY      595.094           50.000  MGD             47.752              1974.0

TOTALS =        10482.703                                  841.166
```

Figure 25 (cont.)

```
                         PERIODIC OPERATING COSTS

PROCESS NAME     OPERATING MAN-HOURS        MAINTAINANCE MAN-HOURS
                   (MAN-HOURS/TP)               (MAN-HOURS/TP)
                 AVE.    MAX.    MIN.       AVE.    MAX.    MIN.

RAW WSTE PMP       0.      0.      0.         0.      0.      0.
PRE TRETMENT       0.      0.      0.         0.      0.      0.
PRIM SETTLER       0.      0.      0.         0.      0.      0.
PRMYSLGE PMP       0.      0.      0.         0.      0.      0.
AERTN BASIN        0.      0.      0.         0.      0.      0.
MECH AERATN     3442.   3442.   3442.      2133.   2133.   2133.
SECY SETTLER    3481.   3481.   3481.      1949.   1949.   1949.
RECIRC PMPNG       0.      0.      0.      1133.   1133.   1133.
CHLORNE FEED       0.      0.      0.         0.      0.      0.
CHLORNE BASN       0.      0.      0.         0.      0.      0.
MUL-MED FLTR    6458.   6458.   6458.         0.      0.      0.
RECIRC PMPNG    2211.   2211.   2211.      1643.   1643.   1643.
GRAV THICKNR       0.      0.      0.         0.      0.      0.
SLGE HLD TNK       0.      0.      0.         0.      0.      0.
VACUUM FILTR       0.     -0.     -0.         0.     -0.     -0.
RECARBONATN1       0.      0.      0.         0.      0.      0.
TER SETTLER1    3481.   3481.   3481.      1949.   1949.   1949.
FECL FEEDING       0.      0.      0.       600.    600.    600.
LIME FEEDING       0.      0.      0.      3070.   3070.   3070.
CO2  FEEDING     808.    808.    808.       431.    431.    431.
RECALCINATN    12106.  12106.  12106.     10950.  10950.  10950.
FLOCC -TRTRY       0.      0.      0.         0.      0.      0.

TOTALS =       31987.  31987.  31987.     23858.  23858.  23858.
```

Figure 25(cont.)

```
                               PERIODIC OPERATING COSTS

PROCESS NAME        MATERIAL & SUPPLY COST                 LABOR COST   TOTAL O&M
                             ( $ /TP)                      (AVERAGE)   (1000$/TP)
                  AVE.          MAX.          MIN.         (1000$/TP)
RAW WSTE PMP        0.0           0.0           0.0           0.0          0.0
PRE TRETMENT        0.0           0.0           0.0           0.0          0.0
PRIM SETTLER        0.0           0.0           0.0           0.0          0.0
PRMYSLGE PMP        0.0           0.0           0.0           0.0          0.0
AERTN BASIN         0.0           0.0           0.0           0.0          0.0
MECH AERATN    118122.00     118122.06     118122.06         25.325      143.447
SECY SETTLER     7493.70       7493.71       7493.71         24.665       32.159
RECIRC PMPNG    10396.82      10396.84      10396.84          5.149       15.546
CHLORNE FEED        0.0           0.0           0.0           0.0          0.0
CHLORNE BASN        0.0           0.0           0.0           0.0          0.0
MUL-MED FLTR    58605.25      58605.35      58605.35         29.335       87.940
RECIRC PMPNG    10396.82      10396.84      10396.84         17.506       27.903
GRAV THICKNR        0.0           0.0           0.0           0.0          0.0
SLGE HLD TNK        0.0           0.0           0.0           0.0          0.0
VACUUM FILTR        0.0           0.0           0.0           0.0          0.0
RECARBONATN1        0.0           0.0           0.0           0.0          0.0
TER SETTLER1     7493.70       7493.71       7493.71         24.665       32.159
FECL FEEDING        0.0           0.0           0.0           2.725        2.725
LIME FEEDING    83652.50      83652.81      83652.81         13.944       97.597
CO2  FEEDING   144110.25     144110.69     144110.69          5.626      149.736
RECALCINATN    282007.00     282007.12     282007.12        104.732      386.739
FLOCC -TRTRY    23624.37      23624.41      23624.41          0.0         23.624

TOTALS =       745902.37     745903.37     745903.37        253.672      999.574
```

Figure 25 (cont.)

```
                              UNIT COST DATA
                           (CENTS/1000 GALLONS)

PROCESS NAME    AMORTIZATION    LABOR    MATERIAL & SUPPLY    TOTAL

RAW WSTE PMP        0.0          0.0           0.0             0.0
PRE TRETMENT        0.0          0.0           0.0             0.0
PRIM SETTLER        0.0          0.0           0.0             0.0
PRMYSLGE PMP        0.0          0.0           0.0             0.0
AERTN BASIN         0.74         0.0           0.0             0.74
MECH AERATN         0.17         0.14          0.65            0.95
SECY SETTLER        0.35         0.14          0.04            0.53
RECIRC PMPNG        0.20         0.03          0.06            0.29
CHLORNE FEED        0.0          0.0           0.0             0.0
CHLORNE BASN        0.0          0.0           0.0             0.0
MUL-MED FLTR        1.81         0.16          0.32            2.29
RECIRC PMPNG        0.33         0.10          0.06            0.49
GRAV THICKNR        0.0          0.0           0.0             0.0
SLGE HLD TNK        0.0          0.0           0.0             0.0
VACUUM FILTR        0.0          0.0           0.0             0.0
RECARBONATN1        0.08         0.0           0.0             0.08
TER SETTLER1        0.35         0.14          0.04            0.53
FECL FEEDING        0.0          0.01          0.0             0.01
LIME FEEDING        0.07         0.08          0.46            0.60
CO2  FEEDING        0.02         0.03          0.79            0.84
RECALCINATN         0.23         0.57          1.55            2.35
FLOCC -TRTRY        0.26         0.0           0.13            0.39

TOTALS =            4.61         1.39          4.09           10.09


                          SOLID SINKS COSTS

TIME      SINK    AMOUNT SOLIDS         COST
PERIOD    USED       (TONS)            ($/TP)

  TOTALS =                   0.0         0.0

UNIT COSTS FOR SOLID WASTE DISPOSAL (CENTS/1000  GAL.) =   0.0
TOTAL UNIT COST (CENTS/1000 GAL) =10.09
```

TABLE 14

TREATMENT SCHEMES

NO.	SYMBOL	SCHEMES	APPENDIX A OPTION DIAGRAM	EFFLUENT PHOSPHORUS (mg/L)
1	ALPYPS	Alum & Polymer to Primary Settler	1	2
2	FCRYPS	Ferric Chloride & Polymer to Primary Settler	1	2
3	FCLMP	Ferrous Chloride & Lime to Primary Settler	1	2
4	LIMEPS	Lime to Primary Settler	1	2
5	ALPYFB	Alum & Polymer to Flocculation Basin	2	2
6	FCPYFB	Ferric Chloride & Polymer to Flocc. Basin	2	2
7	FCLMFB	Ferrous Chloride & Lime to Flocc. Basin	2	2
8	LIMEFB	Lime to the Flocculation Basin	2	2
9	ALUMAB	Alum to the Aeration Basin	3	2
10	FECLAB	Ferric Chloride to Aeration Basin	3	2
11	NAALAB	Sodium Aluminate to Aeration Basin	3	2
12	ALABMF	Alum to Aer. Basin & Multi-Media Filtration	5-A	0.5
13	FCABMF	Ferric Chloride to Aer. Basin & Multi-MediaFil.	5-A	0.5
14	NAABMF	Sodium Aluminate to Aer. Basin & Mul-Med Fil.	5-A	0.5
15	ALUMTF	Alum After Trickling Filter	4	2
16	FECLTF	Ferric Chloride After Trickling Filter	4	2
17	AKTFMF	Alum After Trickling Filter & Multi-Med Filtr.	5-B	0.5
18	FCTFMF	Ferric Chloride After Trk. Fil. & Mul-Med Fil.	5-B	0.5
19	ALFBAS	Alum to Flocc. After Conventional Secondary	7	0.3
20	FCFBAS	Fecl3 to Flocc. After Conventional Secondary	7	0.3
21	LIFBAS	Lime(1-Stage) to Flocc After Conven. Secondary	6-A	0.5
22	L2FBAS	Lime(2-Stage) to Flocc After Conven. Secondary	6-B	0.1
23	NONE	No Chemicals Added for Phosphorus Removal	--	--

SECTION VIII

OPERATING MANUAL FOR THE PHOSPHORUS REMOVAL COST MODEL (REMOVE)

General

This manual describes how REMOVE functions and explains how to interpret the results provided. The manual should be used in conjunction with the descriptive data provided in the other sections of this report. REMOVE is an interactive program which means that it is designed to 'hold a conversation with the user'. The program will ask questions of the user and perform certain operations based on the responses. The program asks the user to describe his/her community and treatment plant. It then inquires about the control strategy the user wishes to evaluate in achieving phosphorus removal. The program then chooses all the various treatment schemes which are to be considered in a particular strategy and starts calculating costs for the first one. Certain errors are detected if input data is outside the range of the cost functions in the model and, if they are, error messages are printed during the cost computations. (See ERRORS section for further explanation.) The user is then asked what type of printout is desired and the printout begins. Following the printout, the next treatment scheme from the list of eligible schemes is considered and its costs are printed out. This is done for each eligible treatment scheme. Control then returns to the strategy design portion of REMOVE. The user may then evaluate additional strategies. Detailed explanations of the questioning and printout follow.

Questioning Procedure

Every variable, whose value is to be set by the user, is input in the following manner: (NOTE: In demonstrating computer/user interaction all computer responses are underscored.)

VNAME = C/R

Where VNAME is the name of the variable and C/R is a carriage return. The user then may type: q, a, m, or a valid input value, followed by a C/R.

q - tells the program that the user did not understand what is wanted and results in the long form of the question being printed. Sometimes, following the long form, certain keywords, enclosed in parentheses, will be printed. These keywords further clarify what type of value is expected by the program and are explained in the KEYWORDS section.

a - tells the program to set the variable to the assumed value. The assumed values are given in the VARIABLES section and represent the 'best known value' at the time the program was last updated.

m - tells the program that the user discovered a mistake in a previously input variable and desires to return to the beginning of this block of variables. (WARNING - be careful about using this as it can result in a lot of repeat typing.) If return is not as far back as desired, then the program must be restarted from the beginning.

valid input value - results in the variable being set to that value. (WARNING - due to IBM limitations on word length, no more than 8 characters are accepted.) (WARNING - there are no checks on the reasonableness of the input values, i.e., a number may be ridiculously large or small and will be accepted as valid.)

non-valid input value - results in the question being repeated.

Below is an example of a sample question period.

```
ELECOS=
q                              (Long form of question is desired)
ELECTRICITY COST ($/KWHR)
a                              (Assumed value is input)
DHR=
q
DIRECT HOURLY LABOR RATE ($/HR)
ew3                            (Non-valid response, question is
                               repeated)
DHR=
4.05                           (User inputs Labor Rate other than
                               assumed)
IDFRAC=
```

The questioning procedure for the variables describing the treatment plant is slightly different than above. The treatment plant consists of a number of processes about which the user can input two pieces of information; the present size (PPARM) and the present loading rate (or design variable, PVAR). So, for the treatment plant, the program will print the treatment process name and ask that PPARM and PVAR be input. A list of the processes and the present size (PPARM) and design variable (PVAR) parameters is presented later in this section.

PRINTOUT

There are three (3) types of printout available for each treatment scheme. They are known as SUPERSHORT, SHORT, and LONG. The program will ask the user if he/she desires a short printout.

If the answer is 'yes', then the program will ask if a supershort printout is desired. Printing then begins. Following the printout for all eligible schemes, the user is asked if he/she desires to select up to five (5) schemes for the LONG printout. The most advantageous use can be made of this feature by first printing all schemes under the SUPERSHORT option and then selecting a few for detailed examination. A complete description and example of each type of printout follow below.

SUPERSHORT -

The output consists of two lines:
LIQUID TREATMENT SCHEME = schno
TOTAL UNIT COST (CENTS/1000 GAL) = xx.xx
Where, schno = number of the treatment scheme, see SCHEME section for further explanation,
xx.xx = total unit cost

LONG -

The output consists of:

1. Treatment scheme number.
2. Miscellaneous
   a. Amortization Rate and Lifetime for all equipment to be built.
   b. Per cent of construction cost financed by federal government.
   c. BOD5 and suspended solids removal in the primary.
3. Construction information for each process in the treatment plant:
   a. process name,
   b. construction cost in $1000,
   c. sizing parameter, i.e., the amount to be built,
   d. amortized cost in $1000 per time period,
   e. the year in which the additional equipment to be built will be first needed,
   f. total for construction cost and amortized cost.
4. Periodic Operating Costs for each process:
   a. process name,
   b. operating man-hours, average, maximum, minimum. The max & min are useful when sewered population is growing to get an idea of just how much costs will increase as time goes on.,
   c. maintainance man-hours,
   d. material & supply costs in $ per time period,
   e. average labor cost computed from the average operating & maintainance man-hours, and the direct & indirect labor rates,
   f. total O & M cost which is the sum of the average labor cost and material & supply cost,
   g. total for each of the above.

5. Unit Cost Data in CENTS/1000 GALLONS for each process:
    a. amortization,
    b. labor,
    c. material & supply,
    d. total of a., b., and c. for each process,
    e. column totals of a., b., c., and d.
6. Cost of Substitutes of Phosphate Detergents:
    a. average, maximum, and minimum cost in $ per time period,
    b. average unit cost in cents/1000 gal.
7. Solid Sink Costs for each time period:
    a. time period,
    b. number of the sink used for that time period, NOTE: If sink number = 99, then all the sinks have been used up and the waste is being dumped in the backyard. See also ERRORS section.,
    c. amount of solids sent to the sink,
    d. cost in $ per time period,
    e. totals for amount of solids and cost,
    f. average unit cost in cents/1000 gal.

SHORT -

The output consists of the titles and column totals from the LONG printout.

KEYWORDS

FLOAT - a floating point number is desired, i.e., a number with a decimal point. For example, 5.7, 35.26, 23., .02. If no decimal point is input, then the number input will be converted to floating point, e.g., 38 will become 38.

FIXED - an integer is expected, i.e., no decimal point. If a decimal point is typed the number will be considered invalid and the question will be repeated.

FRACTION - a decimal fraction is expected, e.g., .52, .02. A number greater than one will not be trapped and most probably will result in invalid results. FRACTION is used most often to signify that a fraction is desired and not a percentage. For example, activated sludge density is usually expressed as a percent, i.e., 5%, this means that the program would expect 5% to be input as .05.

others - other keywords usually indicate the dimensions of the variables. For example:

$/CAP/YR = Dollars per capita per year (This type of operation is always equivalent in the report to $/CAP· YR)

MG/L = Milligrams per liter

VARIABLES

This section contains a list of all the variables whose values may be input by the user. They are listed alphabetically within each group consisting of variables common to an input subroutine. The variable name, a description, dimensions, and assumed value are given for each variable. Test methods for variables requiring measurement are referenced to Standard Methods, 13th Edition.

NOTE: If a variable deals with a treatment process which is not to be considered, then the assumed value may be used safely.

***** Subroutine CMMNTY

CNSTRC
The WQO-STP Construction Cost Index
Dimensions = Index divided by 100.
Assumed Value = 1.714 for MAY 72

DHR
Direct hourly labor rate. Average labor rate for personnel working at the treatment plant including supervisory personnel.
Dimensions = $/Hour
Assumed Value = 3.95 for MAY 72 (S.I.C. 494-497)

ELECOS
Delivered cost of electrical power
Dimensions = $/KWHR
Assumed Value = .01

FNCTYP
A number representing the type of sewered population growth function desired.
Dimensions = none
Assumed Value = 1
Allowable input = 1 (linear growth rate of 5%)
2 (linear growth rate calculated from present pop. and one future pop.)
3 (exponential growth rate calculated from present pop. and one future pop.)
4 (piece-wise linear growth function rate from present pop. and up to four future pop. values)

GOVFF
Fraction of construction cost that will be financed by the federal and state governments.
Dimensions = none
Assumed Value = 0.

IDFRAC
Indirect labor fraction. Indirect labor costs include those labor related costs paid by the utility other than salaries, wages and other direct compensation. Examples of indirect labor costs include social security; contributions to pension, retirement, or welfare funds; and premiums paid on hospitalization, health, life, and workmen's compensation insurance. The costs are specified as a fraction of the base wage and generally average about 15%.
Dimensions = none
Assumed Value = .15 (i.e. 15%)

MATRLS
Wholesale Price Index for Industrial Commodities
Dimensions = Index divided by 100.
Assumed Value = 1.176 for MAY 72

SOLSNK(CAP)
Capacity of solid waste sink. Capacity should be given in terms of the estimated tons a solid waste disposal area will take before it is filled to capacity. It can be estimated by determining how many years of useful life are left times the annual tonnage of sludge material trucked to the site.
Dimensions = Tons
Assumed Value = large (i.e. 10 billion)
Special Input - 99. will cause the subroutine to end input for solid sinks.
Note: Up to fifteen (15) solid sinks may be input.

SOLSNK(DIST)
Distance to solid sink (solid waste disposal site)
Dimensions = Miles
Assumed Value = 0. (which results in zero cost)

SPOPIN(SPOP)
The size of the sewered population. This number is usually given in survey or engineering reports generated by regional planning agencies and represents the present population served by sewers feeding the treatment plant.
Dimensions = Capita
Assumed Value = none
Note: This is input after FNCTYP and up to five (5) population values may be input.
Note: The first SPOPIN input must be the present population and year.

SPOPIN(YEAR)
The year corresponding to the sewered population of SPOPIN(SPOP). This number is the year of the present sewered population estimate and must be entered. It forms the base for the FNCTYP growth functions.

Dimensions = Year (e.g. 1980.)
Assumed Value = none
Special input - 0. will cause the subroutine to proceed to the next variable. This is used to input less than 5 values for a piece-wise linear growth function. [corresponding SPOPIN(SPOP) must be set to zero]

TRNCST
Transportation costs for solid wastes
Dimensions = $/Ton-Mile
Assumed Value = 5.

***** Subroutine SEWAGE

ALKIPS
Alkalinity into the primary settler (Standard Methods, 102)
Dimensions = Milligrams/Liter
Assumed Value = 201.

ASD
Activated sludge density. Ratio of weight of dry sludge to weight of wet sludge. Test method 224G, (Total Residue).
Dimensions = none (Note: 5% is input as .05)
Assumed Value = .01

BODIPS
BOD5 into the primary settler (Standard Methods, 219)
Dimensions = Milligrams/Liter
Assumed Value = 200.

FLOTUD
Air flotation sludge thickener underflow density (Standard Methods, 224G)
Dimensions = none (Note: 5% is input as .05)
Assumed Value = .05

GRAVUD
Gravity sludge thickener underflow density (Standard Methods, 224G)
Dimensions = none (Note: 5% is input as .05)
Assumed Value = .08

HPDFT
Maximum allowable operating hours per day for the air flotation thickener. This number is set by the superintendent of the treatment plant and represents the time available for an operator to run the process or the maximum time per day the superintendent is willing to run the equipment in view of maintenance considerations. For instance, the assumed value of 8 hrs/day is based on a one shift operation. To raise this number would either involve an additional shift or possibly overtime hours.
Dimensions = Hours/Day
Assumed Value = 8.

HPDVF
Maximum allowable operating hours per day for vacuum filter (see above)
Dimensions = Hours/Day
Assumed Value = 8.

MLSSAR
Mixed liquor suspended solids in the aeration process (Test method 224C, Total Suspended Matter)
Dimensions - Milligrams/Liter
Assumed Value = 2000.

NH31AR
NH3 concentration into the aeration process (Standard Methods, 212)
Dimensions = Milligrams/Liter
Assumed Value = 0.

PINPS
Phosphorus concentration into the primary settler (Total Phosphorus - Standard Methods, 223C)
Dimensions = Milligrams/Liter
Assumed Value = 10.

PSETUD
Primary settler underflow sludge density (Standard Methods, 224G)
Dimensions = none (Note: 5% in input as .05)
Assumed Value = .05

PSRMVE
Fraction of suspended solids removed in primary settler. This is the ratio of suspended solids in the effluent from the primary settler to the suspended solids in the influent.
Dimensions = none
Assumed Value = .5

QAVE
Average daily flow
Dimensions = Million Gallons/Day
Assumed Value = 10.

QPEAK
Peak diurnal flow
Dimensions = Million Gallons/Day
Assumed Value = 19.

SSINPS
Suspended solids into the primary settler (Standard Methods, 224C)
Dimensions = Milligrams/Liter
Assumed Value = 200.

TBODAR
Total change in BOD5 across aeration process
(i.e., the fraction removed)
Dimensions = none
Assumed Value = .85

VFPSLG
Volatile fraction of primary sludge (Standard Methods, 224G Volatile Residue)
Dimensions = none
Assumed Value = .78

VSANRM
Volatile sludge fraction remaining after anaerobic digestion (Standard Methods, 224G Volatile Residue)
Dimensions = none
Assumed Value = .5

VSARM
Volatile sludge fraction remaining after aerobic digestion (Standard Methods, 224G Volatile Residue)
Dimensions = none
Assumed Value = .5

***** Subroutine PLANT

AMRATE
Amortization rate for all equipment to be built
Dimensions - none
Assumed Value = .05 (i.e., 5%)

AMLIFE
Amortization lifetime for all equipment to be built
Dimensions = years
Assumed Value = 20.

The following variables describe the equipment (processes) comprising the treatment plant. For each process there are two variables which describe it.

PPARM
The present independent sizing parameter
Dimensions = see below for a particular process
Assumed Value = 0.
Special Input - 99. indicates the end of process description data and execution proceeds to the next subroutine.
- -1. indicates that the plant is to have this process but its present size is set to zero.

PVAR
The present design variable
Dimensions = see below for a particular process
Assumed Value = see below for a particular process
Note: If PPARM = 0., then PVAR is set to its assumed value automatically. In some cases, there will be no PVAR for a particular process. Although the program does not in these cases need this value to calculate costs, the program due to programming limitations will request a value. The assumed value which is zero can be safely entered.

PROCESSES -

1	RWPUMP	RAW WASTEWATER PUMPING
2	PRETRT	PRELIMINARY TREATMENT
3	PRMSET	PRIMARY SETTLER
4	PSPUMP	PRIMARY SLUDGE PUMPING
5	TRKFTR	TRICKLING FILTER (SINGLE MEDIA)
6	AERBSN	AERATION BASIN
7	DIFAIR	DIFFUSED AIR SYSTEM
8	MCHAER	MECHANICAL AERATION
9	FLOCCP	FLOCCULATION BEFORE PRIMARY
10	SECSET	SECONDARY SETTLER
11	RE1PMP	RECIRCULATION PUMPING
12	CLFEED	CHLORINE FEED SYSTEM
13	CLBASN	CHLORINATION CONTACT BASIN
14	MULFTR	MULT-MEDIA FILTER
15	RE2PMP	RECIRCULATION PUMPING
16	GRVTKN	GRAVITY THICKNER
17	FLOTKN	AIR FLOTATION THICKNER
18	ANADIG	ANAEROBIC DIGESTION
19	AERDIG	AEROBIC DIGESTION
20	DRYBED	SLUDGE DRYING BED
21	SLDTNK	SLUDGE HOLDING TANK
22	VACFTR	VACUUM FILTER
23	CENFUG	CENTRIFUGE
24	MHINC	MULTIPLE HEARTH INCINERATOR
25	FBINC	FLUIDIZED BED INCINERATOR
26	WSPOND	WASTE STABILIZATION POND
27	SLGOON	SLUDGE LAGOON
28	RECRB1	RE-CARBONATION
29	RECRB2	RE-CARBONATION
30	TERST1	TERTIARY SETTLER
31	TERST2	TERTIARY SETTLER
32	ALUMFS	ALUM FEEDING AND STORAGE
33	FECLFS	FERRIC CHLORIDE FEEDING AND STORAGE
34	LIMEFS	LIME FEEDING AND STORAGE
35	POLYFS	POLYMER FEEDING AND STORAGE

36	CO2FS	CO2	FEEDING AND STORAGE
37	NAALFS	SODIUM ALUMINATE	FEEDING AND STORAGE
38	PCKLFS	PICKLING LIQUOR	FEEDING AND STORAGE
39	NAOHFS	SODIUM HYDROXIDE	FEEDING AND STORAGE
40	RECALC	RECALCINATION	
41	FLOCCT	FLOCCULATION BEFORE TERTIARY	

DESCRIPTIONS AND DIMENSIONS OF PARM AND VAR FOR EACH PROCESS FOLLOW:

PARM = INDEPENDENT SIZING PARAMETER
VAR = DESIGN VARIABLE

RWPUMP: PARM - INITIAL FIRM CAPACITY (MGD). The total capacity of the original installation with the largest pumping unit out of service. If a plant had three raw waste pumps each with 1 MGD capacity, the initial firm capacity would be 2 MGD.

PRETRT: PARM - MAXIMUM CAPACITY (MGD)

PRMSET: PARM - SURFACE AREA OF SETTLER (THOS. SQ. FT.)
VAR - DESIGN OVERFLOW RATE (GPD/SQ.FT.) Design flow divided by surface area of the settler.
Assumed value for VAR = 700.

PSPUMP: PARM - INITIAL FIRM CAPACITY (GPM) Same as above.
VAR - OPERATING HOURS (HOURS/DAY)
Assumed value for VAR = 4.

TRKFTR: PARM - MEDIA VOLUME (THOS. CU. FT.) Media depth multiplied by surface area.
VAR - HYDRAULIC LOADING (MGD/ACRE)
Assumed value for VAR - 5.

AERBSN: PARM - LIQUID VOLUME (THOS. CU. FT.)
VAR - DETENTION TIME (HOURS)
Assumed value for VAR = 6.

DIFAIR: PARM - INITIAL FIRM BLOWER CAPACITY (THOS. CFM) The total capacity of the original installation with the largest blower unit out of service.
VAR - DIFFUSER EFFICIENCY (FRACTION) lbs oxygen absorbed divided by lbs of oxygen supplied.
Assumed value for VAR = .05

MCHAER: PARM - TOTAL INSTALLED CAPACITY (HP)
VAR - TRANSFER EFFICIENCY (LBS 02/HP-HR) (Number specified by supplier of the aeration equipment)
Assumed value for VAR = 3.5

FLOCCP: PARM - MAXIMUM CAPACITY (MGD)

SECSET: PARM - SURFACE AREA OF SETTLER (THOS. SQ. FT.)
VAR - DESIGN OVERFLOW RATE (GPD/SQ. FT.)
Assumed value for VAR = 700.

RE1PMP: PARM - MAXIMUM CAPACITY (MGD)

CLFEED: PARM - AVERAGE CHLORINE USE (LBS/DAY)
VAR - CHLORINE DOSAGE (MG/L)
Assumed value for VAR = 8.

CLBASN: PARM - LIQUID VOLUME (THOS. CU. FT.)
VAR - CHLORINE CONTACT TIME (MINUTES)
Assumed value for VAR - 15.

MULFTR: PARM - CAPACITY (MGD). Limited cost data is available on multi-media filter installations. The cost information used by the program is a function of the effluent passed through the filter. The number requested is the flow rate of secondary effluent through the filter.

RE2PMP: PARM - MAXIMUM CAPACITY (MGD)

GRVTKN: PARM - SURFACE AREA (THOS. SQ. FT.)
VAR - DESIGN LOADING RATE (LBS/DAY/SQ. FT.)
Assumed value for VAR = 20.

FLOTKN: PARM - SURFACE AREA (SQ. FT.)
VAR - LOADING RATE (LB/HR/SQ. FT.)
Assumed value for VAR = 2.

ANADIG: PARM - SLUDGE VOLUME (THOS. CU. FT.)
VAR - DETENTION TIME (DAYS)
Assumed value for VAR = 15.

AERDIG: PARM - SLUDGE VOLUME (THOS. CU. FT.)
VAR - DETENTION TIME (DAYS)
Assumed value for VAR = 15.

DRYBED: PARM - SURFACE AREA OF BEDS (THOS. SQ. FT.)
VAR - REQUIRED BED AREA (SQ. FT./CAPITA) Sludge bed loadings are computed on a per capita basis. Typical ranges for chemical sludges are 2.0 - 2.5 for open beds and 1.25 - 1.5 for covered beds.
Assumed value for VAR = 2.3

SLDTNK: PARM = SLUDGE VOLUME (THOS. CU. FT.)
VAR - DETENTION TIME (HOURS)
Assumed value for VAR = 4.

VACFTR: PARM - FILTER AREA (SQ. FT.)
VAR - LOADING RATE (LBS/HR/SQ. FT.)
Assumed value for VAR = 4.5

CENFUG: PARM - FIRM CAPACITY (GPM) Rated capacity of the centrifuge.
VAR - OPERATING TIME (FRACTION OF DAY)
Assumed value for VAR = 34.

MHINC: PARM - CAPACITY (LBS DRY SOLIDS/HR)
VAR - OPERATING TIME (HOURS/DAY)
Assumed value for VAR = 8.

FBINC: PARM - CAPACITY (LBS DRY SOLIDS/HR)
VAR - OPERATING TIME (HOURS/DAY)
Assumed value for VAR = 8.

WSPOND: PARM - VOLUME OF SLUDGE (THOS. CU. FT.)
VAR - DETENTION TIME (DAYS)

SLGOON: PARM - SLUDGE VOLUME (THOS. CU. FT.)
VAR - DETENTION TIME (DAYS)
Assumed value for VAR = 0.

RECRB1: PARM - LIQUID VOLUME (THOS. CU. FT.)
VAR - DETENTION TIME (MINUTES)
Assumed value for VAR = 30.

RECRB2: PARM - LIQUID VOLUME (THOS. CU. FT.)
VAR - DETENTION TIME (MINUTES)
Assumed value for VAR = 30.

TERST1: PARM - SURFACE AREA OF SETTLER (THOS. SQ. FT.)
VAR - DESIGN OVERFLOW RATE (GPD/SQ. FT.) Flow volume divided by surface area of the settler.
Assumed value for VAR = 700.

TERST2: PARM - SURFACE AREA OF SETTLER (THOS. SQ. FT.)
VAR - DESIGN OVERFLOW RATE (GPD/SQ. FT.)
Assumed value for VAR = 700.

ALUMFS: PARM - CHEMICAL USAGE (LBS AL/DAY)
VAR - COST OF CHEMICAL ($/LB ALUM) The cost desired is the dollars per pound of dry alum charged to the treatment plant. If the plant receives liquid alum, the charge should be converted to a dry alum basis assuming that liquid alum has a density of 11.1 lb/gal at 60°F and there are 5.4 lb dry alum per gallon of liquid.
Assumed value for VAR = .03

FECLFS: PARM - CHEMICAL USAGE (LBS FE/DAY)
VAR - COST OF CHEMICAL ($/LB FECL3)
Assumed value for VAR = .042

LIMEFS: PARM - CHEMICAL USAGE (LBS CAO/DAY)
VAR - COST OF CHEMICAL ($/LB CAO)
Assumed value for VAR = .01

POLYFS: PARM - CHEMICAL USAGE (LBS/DAY)
VAR - COST OF CHEMICAL ($/LB POLY)
Assumed value for VAR = 1.5

CO2FS: PARM - CHEMICAL USAGE (1000 cu. ft. min)
VAR - COST OF CHEMICAL ($/LB CO2)
Assumed value for VAR = .023

NAALFS: PARM - CHEMICAL USAGE (LBS AL/DAY)
VAR - COST OF CHEMICAL ($/LB NAAL) The cost desired is the dollars per pound of dry sodium aluminate charged to the treatment plant. Liquid sodium aluminate has considerable variation in density and viscosity, thus the manufacturer's data should be checked to convert the cost of liquid sodium aluminate to an equivalent dry cost.
Assumed value for VAR = .12

PCKLFS: PARM - CHEMICAL USAGE (LBS FE/DAY)
VAR - COST OF CHEMICAL ($/LB FECL2)
Assumed value for VAR = .04

NAOHFS: PARM - CHEMICAL USAGE (LBS/DAY)
VAR - COST OF CHEMICAL ($/LB NAOH)
Assumed value for VAR = 0.

RECALC: PARM - MAXIMUM CAPACITY (MGD)

FLOCCT: PARM - MAXIMUM CAPACITY (MGD)

***** Subroutine INTIME

NOYRS
Number of years in desired time horizon
Dimensions = Years
Assumed Value = 20

TPSIZE
Size of time periods in desired time horizon
Dimensions = Years
Assumed Value = 1.

***** Subroutine EFFLIM

ELIMIT
Desired phosphorus effluent limit
Dimensions = Milligrams/Liter
Assumed Value = 99.
Special Input - 99. indicates end of effluent data and execution continues with the next subroutine.
Note: Up to 20 limits and years may be input

EYEAR
Year of effluent implementation
Dimensions = Years
Assumed Value = 0.
Note: Subroutine EFFLIM expects EYEAR to increase each time it is input.

***** Subroutine DTGLIM

DIFCOS
Differential cost between old and new detergents. This number is the difference in cost between a new detergent product replacing a phosphate containing detergent as a result of local legislation. The new product may contain no phosphate or it may contain some reduced amount depending on the legislation. DIFCOS is the extra cost of replacing one pound of phosphate with a substitute.
Dimensions = $/Pound Detergent
Assumed Value = .02

DTRGUS
Annual per capita detergent usage
Dimensions = Pounds/Capita/Year
Assumed Value = 27.
Note: 27. is equivalent to 90% of phosphorus in influent wastewater resulting from detergents.
Use 16. to get 50%.

ENFCST
Enforcement cost of phosphate restrictions
Dimensions = $/Capita/Year
Assumed Value = .4

PCNTNT
Proposed legislated phosphorus content in detergent. Up to five values are accepted. The variable PYEAR requests the year of implementation of the legislative restrictions.
Dimensions = none (Note: 3% is input as .03)
Assumed Value = 99.
Special Input - 99. indicates end of limit data and execution proceeds to read in the next variable.

PRESPC
Present legislated phosphorus content in detergents. If the community has passed legislation limiting phosphorus in detergents, what is the percent allowed?
Dimensions = none
Assumed Value = .1 (i.e. 10%)

PYEAR
Year of implementation corresponding to a PCNTNT
Dimensions = Year (e.g., 1982.)
Assumed Value = 0.
Note: DTGLIM expects PYEAR to increase in value each time it is input.

ERRORS

1. Since linear and polynomial curve fitting techniques were used to obtain the mathematical cost relationships that are used in the program, the cost calculations are valid only over the range of the regression data points used to generate the cost equations. If an input value to the construction cost equations lies outside this range, a warning message is printed. This informs the user that the construction cost, operating and maintainance man-hours, and material & supply costs may be inaccurate for this process. The warning message is of the form:

```
***** WARNING - THE VALUE OF THE SIZING PARAMETER
FOR PROCESS 'pname' = pvalue LIES OUTSIDE THE RANGE
minvalue TO maxvalue
```

where: pname = name of process
pvalue = value of parameter
minvalue = minimum value of range
maxvalue = maximum value of range

2. Because it is possible to run out of capacity in the solid sinks, a warning message will be printed when this occurs. The message is of the form:

***** WARNING - ALL SOLID SINKS ARE COMPLETELY FILLED

SCHEME

The following chemical treatment schemes have been selected to provide varying levels of phosphorus in the effluent.

1	ALPYPS	ALUM + POLYMER TO PRIMARY SETTLER
2	FCPYPS	FERRIC CHLORIDE + POLYMER TO PRIMARY SETTLER
3	FCLMPS	FERROUS CHLORIDE + LIME TO PRIMARY SETTLER
4	LIMEPS	LIME TO PRIMARY SETTLER
5	ALPYFB	ALUM + POLYMER TO FLOCCULATION BASIN
6	FCPYFB	FERRIC CHLORIDE + POLYMER TO FLOCC. BASIN
7	FCLMFB	FERROUS CHLORIDE + LIME TO FLOCC. BASIN
8	LIMEFB	LIME TO THE FLOCCULATION BASIN
9	ALUMAB	ALUM TO THE AERATION BASIN
10	FECLAB	FERRIC CHLORIDE TO AERATION BASIN
11	NAALAB	SODIUM ALUMINATE TO AERATION BASIN
12	ALABMF	ALUM TO AER. BASIN + MULTI-MEDIA FILTRATION
13	FCABMF	FERRIC CHLORIDE TO AER. BASIN + MULTI-MEDIA FIL
14	NAABMF	SODIUM ALUMINATE TO AER. BASIN + MUL-MED FILTR.
15	ALUMTF	ALUM AFTER TRICKLING FILTER
16	FECLTF	FERRIC CHLORIDE AFTER TRICKLING FILTER
17	ALTFMF	ALUM AFTER TRICKLING FILTER + MUL-MED FILTR.
18	FCTFMF	FERRIC CHLORIDE AFTER TRK. FIL. + MUL-MED FILTR.
19	ALFBAS	ALUM TO FLOCC. AFTER CONVENTIONAL SECONDARY
20	FCFBAS	FECL3 TO FLOCC. AFTER CONVENTIONAL SECONDARY
21	L1FBAS	LIME (1-STAGE) TO FLOCC AFTER CONVEN. SECONDARY
22	L2FBAS	LIME (2-STAGE) TO FLOCC AFTER CONVEN. SECONDARY
23	NONE	NO CHEMICALS ADDED FOR PHOSPHORUS REMOVAL

```
                         LONG PRINTOUT EXAMPLE


LIQUID TREATMENT SCHEME =    17
AMORTIZATION RATE =0.05 AMORTIZATION LIFETIME =20.0
FRACTION OF CONSTRUCTION COST FINANCED BY GOVERNMENT  = .0

PROCESS NAME    CONSTRUCTION        SIZING              AMORTIZED COST        YEAR PROCESS
               COST(1000 $ )      PARAMETER              (1000 $ /TP)         FIRST NEEDED

RAW WSTE PMP         0.0             0.0    MGD                0.0               1994.0
PRE TRETMENT         0.0             0.0    MGD                0.0               1994.0
PRIM SETTLER         0.0             0.0    TSF                0.0               1994.0
PRMYSLGE PMP         0.0             0.0    GPM                0.0               1994.0
TRKLNG FILTR      1491.811        1045.440  TCF              119.708             1974.0
SECY SETTLER         0.0             0.0    TSF                0.0               1994.0
RECIRC PMPNG         0.0             0.0    MGD                0.0               1994.0
CHLORNE FEED         0.0             0.0    #/D                0.0               1994.0
CHLORNE BASN         0.0             0.0    TCF                0.0               1994.0
MUL-MED FLTR      1870.254          20.000  MGD              150.075             1974.0
RECIRC PMPNG       372.327          38.000  MGD               29.877             1974.0
GRAV THICKNR         0.0             0.0    TSF                0.0               1994.0
SLGE HLD TNK        56.405          12.796  TCF                4.526             1974.0
VACUUM FILTR         0.0             0.0    SQFT               0.0               1994.0
ALUM FEEDING       106.520        2499.000  #/D                8.548             1974.0
FECL FEEDING        45.525         334.353  #/D                3.653             1974.0
LIME FEEDING        47.918        3865.117  #/D                3.845             1974.0

TOTALS =           3990.760                                  320.231
```

```
                                PERIODIC OPERATING COSTS
   PROCESS NAME     OPERATING MAN-HOURS      MAINTAINANCE MAN-HOURS
                      (MAN-HOURS/TP)            (MAN-HOURS/TP)
                    AVE.     MAX.     MIN.    AVE.     MAX.     MIN.

   RAW WSTE PMP       0.       0.       0.      0.       0.       0.
   PRE TRETMENT       0.       0.       0.      0.       0.       0.
   PRIM SETTLER       0.       0.       0.      0.       0.       0.
   PRMYSLGE PMP       0.       0.       0.      0.       0.       0.
   TRKLNG FILTR    1449.    1449.    1449.    925.     925.     925.
   SECY SETTLER       0.       0.       0.      0.       0.       0.
   RECIRC PMPNG       0.       0.       0.      0.       0.       0.
   CHLORNE FEED       0.       0.       0.      0.       0.       0.
   CHLORNE BASN       0.       0.       0.      0.       0.       0.
   MUL-MED FLTR    3772.    3772.    3772.      0.       0.       0.
   RECIRC PMPNG    1153.    1153.    1153.    971.     971.     971.
   GRAV THICKNR       0.       0.       0.      0.       0.       0.
   SLGE HLD TNK     134.     134.     134.     80.      80.      80.
   VACUUM FILTR    4391.    4391.    4391.    536.     536.     536.
   ALUM FEEDING       0.       0.       0.   3012.    3012.    3012.
   FECL FEEDING       0.       0.       0.    765.     765.     765.
   LIME FEEDING       0.       0.       0.   2182.    2182.    2182.

   TOTALS =       10898.   10898.   10898.   8470.    8470.    8470.
```

```
                         PERIODIC OPERATING COSTS

                   MATERIAL & SUPPLY COST            LABOR COST   TOTAL O&M
                          ( $ /TP)                   (AVERAGE)    (1000$/TP)
PROCESS NAME        AVE.         MAX.         MIN.   (1000$/TP)

RAW WSTE PMP          0.0          0.0          0.0       0.0         0.0
PRE TRETMENT          0.0          0.0          0.0       0.0         0.0
PRIM SETTLER          0.0          0.0          0.0       0.0         0.0
PRMYSLGE PMP          0.0          0.0          0.0       0.0         0.0
TRKLNG FILTR       1819.04      1819.04      1819.04     10.046      11.865
SECY SETTLER          0.0          0.0          0.0       0.0         0.0
RECIRC PMPNG          0.0          0.0          0.0       0.0         0.0
CHLORNE FEED          0.0          0.0          0.0       0.0         0.0
CHLORNE BASN          0.0          0.0          0.0       0.0         0.0
MUL-MED FLTR      25175.88     25175.92     25175.92     15.961      41.137
RECIRC PMPNG       7707.08      7707.10      7707.10      8.985      16.692
GRAV THICKNR          0.0          0.0          0.0       0.0         0.0
SLGE HLD TNK        486.36       486.36       486.36      0.904       1.390
VACUUM FILTR      21644.56     21644.59     21644.59     20.852      42.497
ALUM FEEDING     301004.00    301004.37    301004.37     12.745     313.749
FECL FEEDING      14813.01     14813.06     14813.06      3.239      18.052
LIME FEEDING      14107.63     14107.67     14107.67      9.233      23.340

TOTALS =         386757.50    386758.00    386758.00     81.964     468.721
```

```
                         UNIT COST DATA
                       (CENTS/1000 GALLONS)

PROCESS NAME   AMORTIZATION   LABOR   MATERIAL & SUPPLY   TOTAL

RAW WSTE PMP      0.0          0.0          0.0            0.0
PRE TRETMENT      0.0          0.0          0.0            0.0
PRIM SETTLER      0.0          0.0          0.0            0.0
PRMYSLGE PMP      0.0          0.0          0.0            0.0
TRKLNG FILTR      1.64         0.14         0.02           1.80
SECY SETTLER      0.0          0.0          0.0            0.0
RECIRC PMPNG      0.0          0.0          0.0            0.0
CHLORNE FEED      0.0          0.0          0.0            0.0
CHLORNE BASN      0.0          0.0          0.0            0.0
MUL-MED FLTR      2.06         0.22         0.34           2.62
RECIRC PMPNG      0.41         0.12         0.11           0.64
GRAV THICKNR      0.0          0.0          0.0            0.0
SLGE HLD TNK      0.06         0.01         0.01           0.08
VACUUM FILTR      0.0          0.29         0.30           0.58
ALUM FEEDING      0.12         0.17         4.12           4.42
FECL FEEDING      0.05         0.04         0.20           0.30
LIME FEEDING      0.05         0.13         0.19           0.37

TOTALS =          4.39         1.12         5.30          10.81
                   SOLID SINKS COSTS

TIME     SINK    AMOUNT SOLIDS       COST
PERIOD   USED       (TONS)          ($/TP)
    1      1        3648.54       91213.44
    2      1        3648.54       91213.44
    3      1        3648.54       91213.44
    4      1        3648.54       91213.44
    5      1        3648.54       91213.44
    6      1        3648.54       91213.44
    7      1        3648.54       91213.44
    8      1        3648.54       91213.44
    9      1        3648.54       91213.44
   10      1        3648.54       91213.44
   11      1        3648.54       91213.44
   12      1        3648.54       91213.44
   13      1        3648.54       91213.44
   14      1        3648.54       91213.44
   15      1        3648.54       91213.44
   16      1        3648.54       91213.44
   17      1        3648.54       91213.44
   18      1        3648.54       91213.44
   19      1        3648.54       91213.44
   20      1        3648.54       91213.44

  TOTALS =         72970.69     1824265.00

UNIT COSTS FOR SOLID WASTE DISPOSAL (CENTS/1000  GAL.) =  1.25
TOTAL UNIT COST (CENTS/1000 GAL) =12.06
```

ERRATA SHEET FOR THE PROGRAM LISTING

NOTE: Statement # n+m means Fortran statement number n + m lines

Subroutine: CONCST

Statement # 6790 + 1
should read X = TPLANT (BPARM, RECALC)
Statement # 6790 + 2
should read 'REF. 13', not "REF. 12'

Subroutine: SIZE

Statement # 4000 + 22
which reads 'PFECL = PFECL + WRFEP* ...'
should be replaced by the following 6 lines:

```
C       FE CAN BE ADDED AS EITHER FECL3 OR FECL2
C       IF FECL3, THEN FFRATO = 2.89
C       IF FECL2, THEN FFRATO = 2.27
        FECON = WRFEP * IELIMT(INF, TP) * FFRATO * CON
        IF (FFRATO .EQ. 2.89) PFECL = PFECL + FECON
        IF (FFRATO .EQ. 2.27) PPCKL = PPCKL + FECON
```

Subroutine: TSCHEME

Statement # 5700
Insert before this statement the following line:

```
RETURN
```

```
FILE: BLKDAT   FORTRAN  P1                              INTERACTIVE DATA CORPORATION

      BLOCK DATA
C
C        PURPOSE:
C           BLOCK DATA CONTAINS DATA STATEMENTS USED TO INITIALIZE
C           VARIABLES IN NAMED COMMON.
C
C        COMMON BLOCKS:
C           IELIMT - INFLUENT/EFFLUENT INFORMATION
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           SCHEME - INFO ABOUT LIQUID TREATMENT SCHEMES
C           SEWPOP - THE SEWERED POPULATION
C           SSINK  - SOLID SINK INFORMATION
C           TPLANT - THE TREATMENT PLANT CHARACTERISTICS
C
C        AUTHOR:
C           DAVID A BARNES   17OCT72
C
C        ----------------------------------------------------------------
      COMMON /IELIMT/ IELIMT(2,20)
     1 , INF, EFF

      REAL IELIMT
      INTEGER EFF

      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
     1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
     2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
     3 , ALTFMF, FCTFMF, ALFBAS, FCFBAS, L1FBAS, L2FBAS, NONE
     4 , EQUIP(45)

      INTEGER ELGBTY, EQUIP, SCHEME
      INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
     1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTFMF, FCTFMF, ALFBAS
     2 , FCFBAS
      REAL MINEFP

      COMMON /SEWPOP/ FNCTYP, SPOPIN(2,5), SEWPOP(20)
     1 , YEAR, SPOP, MAXPV

      INTEGER YEAR, SPOP, FNCTYP

      COMMON /SSINK/ TRNCST, SWASTE(20), SOLSNK(2,15), SSCOST(20)
     1               , BESTSS(20), CAP, DIST, MAXSS
      INTEGER BESTSS, CAP, DIST
      COMMON /TPLANT/ TPLANT(16,45)
     1 , RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHASR, FLOCCP, SECSET, RF1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGCON, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
     6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     8 , WVAR  , BPARM , BASE  , APVAR , PARMX , MINRV , MAXRV
     9 , MAXP

      INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
     1 , DIFAIR, FLOCCP, SECSET, RF1PMP, CLFEED, CLBASN, RE2PMP
     2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
     3 , CENFUG, FBINC , WSPOND, SLGCON, RECRB1, RECRB2, TERST1
     4 , TERST2, ALUMFS, FECLFS, POLYFS, CO2FS , PCKLFS, RECALC
     5 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     6 , WVAR  , BPARM , FLOCCT, BASE  , APVAR , PARMX


C         ***** IFLIMT *****
      DATA INF/1/, EFF/2/
C
C         ***** PRGCNT *****
      DATA FIXED/1/, FLOTE/2/, ALPHA/3/
      DATA YES/3HYES/, NO/2HNO/
      DATA ON/1/, OFF/0/
C
C         ***** SEWPCP *****
      DATA YEAR/2/, SPOP/1/, MAXPV/5/
C
C         ***** SSINK *****
      DATA CAP/1/, DIST/2/, MAXSS/15/
C
C         ***** SCHEME *****
      DATA MAXSCM/25/
C         SCHEME NAMES AND NUMBERS
      DATA ALPYPS/1/, FCPYPS/2/, FCLMPS/3/, LIMEPS/4/, ALPYFB/5/
     1 , FCPYFB/ 6/, FCLMFB/ 7/, LIMEFB/ 8/, ALUMAB/ 9/, FECLAB/10/
     2 , NAALAB/11/, ALABMF/12/, FCABMF/13/, NAABMF/14/, ALUMTF/15/
     3 , FECLTF/16/, ALTFMF/17/, FCTFMF/18/, ALFBAS/19/, FCFBAS/20/
     4 , L1FBAS/21/, L2FBAS/22/, NONE/23/
C         LIQUID TREATMENT PROCESSES FOR EACH SCHEME
      DATA SCHEME(1,1) /32/, SCHEME(2,1) /35/
      DATA SCHEME(1,2) /33/, SCHEME(2,2) /35/
      DATA SCHEME(1,3) /34/, SCHEME(2,3) /33/
      DATA SCHEME(1,4) /34/
      DATA SCHEME(1,5) /32/, SCHEME(2,5) /35/, SCHEME(3,5) / 9/
      DATA SCHEME(1,6) /33/, SCHEME(2,6) /35/, SCHEME(3,6) / 9/
      DATA SCHEME(1,7) /34/, SCHEME(2,7) /38/, SCHEME(3,7) / 9/
      DATA SCHEME(1,8) /34/, SCHEME(2,8) / 9/
      DATA SCHEME(1,9) /32/, SCHEME(2,9) / 6/
      DATA SCHEME(1,10) /33/, SCHEME(2,10) /6/
      DATA SCHEME(1,11) /37/, SCHEME(2,11) /6/
      DATA SCHEME(1,12) /14/, SCHEME(2,12) /15/, SCHEME(3,12) /32/
```

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```
     1 , SCHEME(4,12) /6/
      DATA SCHEME(1,13) /14/, SCHEME(2,13) /15/, SCHEME(3,13) /33/
     1 , SCHEME(4,13) /6/
      DATA SCHEME(1,14) /14/, SCHEME(2,14) /15/, SCHEME(3,14) /37/
     1 , SCHEME(4,14) /6/
      DATA SCHEME(1,15) /32/, SCHEME(2,15) /5/
      DATA SCHEME(1,16) /33/, SCHEME(2,16) /5/
      DATA SCHEME(1,17) /14/, SCHEME(2,17) /15/, SCHEME(3,17) /32/
     1 , SCHEME(4,17) /5/
      DATA SCHEME(1,18) /14/, SCHEME(2,18) /15/, SCHEME(3,18) /33/
     1 , SCHEME(4,18) /5/
      DATA SCHEME(1,19) /14/, SCHEME(2,19) /15/, SCHEME(3,19) /30/
     1 , SCHEME(4,19) /32/, SCHEME(5,19) /41/
      DATA SCHEME(1,20) /14/, SCHEME(2,20) /15/, SCHEME(3,20) /30/
     1 , SCHEME(4,20) /33/, SCHEME(5,20) /41/
      DATA SCHEME(1,21) /14/, SCHEME(2,21) /15/, SCHEME(3,21) /28/
     1 , SCHEME(4,21) /30/, SCHEME(5,21) /34/, SCHEME(6,21) /36/
     2 , SCHEME(7,21) /41/
      DATA SCHEME(1,22) /14/, SCHEME(2,22) /15/, SCHEME(3,22) /28/
     1 , SCHEME(4,22) /29/, SCHEME(5,22) /30/, SCHEME(6,22) /31/
     2 , SCHEME(7,22) /34/, SCHEME(8,22) /36/, SCHEME(9,22) /41/
C        MINIMUM ACHIEVABLE EFFLUENT P LEVELS FOR EACH SCHEME
      DATA MINEFP( 1)/2./, MINEFP( 2)/2./, MINEFP( 3)/2./
     1   , MINEFP( 4)/2./, MINEFP( 5)/2./, MINEFP( 6)/2./
     2   , MINEFP( 7)/2./, MINEFP( 8)/2./, MINEFP( 9)/2./
     3   , MINEFP(10)/2./, MINEFP(11)/2./, MINEFP(12)/.5/
     4   , MINEFP(13)/.5/, MINEFP(14)/.5/, MINEFP(15)/2./
     5   , MINEFP(16)/2./, MINEFP(17)/.5/, MINEFP(18)/.5/
     6   , MINEFP(19)/.3/, MINEFP(20)/.3/, MINEFP(21)/.5/
     7   , MINEFP(22)/.1/, MINEFP(23)/10./
C
C
C        ***** TPLANT *****
C
      DATA MAXP/45/
C        TREATMENT PROCESSES NAMES AND NUMBERS
      DATA RWPUMP/1/, PRETRT/2/, PRMSET/3/, PSPUMP/4/, TRKFTR/5/
     1 , AERBSN/ 6/, DIFAIR/ 7/, MCHAER/ 8/, FLOCCP/ 9/, SECSET/10/
     2 , RE1PMP/11/, CLFEED/12/, CLBASN/13/, MULFTR/14/, RE2PMP/15/
     3 , GRVTKN/16/, FLOTKN/17/, ANADIG/18/, AERDIG/19/, DRYBED/20/
     4 , SLDTNK/21/, VACFTR/22/, CENFUG/23/, MHINC /24/, FBINC /25/
     5 , WSPOND/26/, SLGCON/27/, RECRB1/28/, RECRB2/29/, TERST1/30/
     6 , TERST2/31/, ALUMFS/32/, FECLFS/33/, LIMEFS/34/, POLYFS/35/
     7 , CO2FS /36/, NAALFS/37/, PCKLFS/38/, NAOHFS/39/, RECALC/40/
     8 , FLOCCT/41/
      DATA PNAME/1/, AMRATE/4/, AMLIFE/5/, PPARM/6/, PVAR/7/
     1 , WOPARM/ 8/, WPARM / 9/, WVAR  /10/, BPARM /11/, BASE  /12/
     2 , APVAR /13/, PARMX /14/, MINRV/15/, MAXRV/16/
C        TREATMENT PROCESS NAMES FOR PRINTOUT
      DATATPLANT(1, 1)/4HRAW /,TPLANT(2, 1)/4HWSTE/,TPLANT(3, 1)/4H PMP/
      DATATPLANT(1, 2)/4HPRE /,TPLANT(2, 2)/4HTRET/,TPLANT(3, 2)/4HMENT/
      DATATPLANT(1, 3)/4HPRIM/,TPLANT(2, 3)/4H SET/,TPLANT(3, 3)/4HTLER/
      DATATPLANT(1, 4)/4HPRMY/,TPLANT(2, 4)/4HSLGE/,TPLANT(3, 4)/4H PMP/
      DATATPLANT(1, 5)/4HTRKL/,TPLANT(2, 5)/4HNG F/,TPLANT(3, 5)/4HILTR/
      DATATPLANT(1, 6)/4HAERT/,TPLANT(2, 6)/4HN BA/,TPLANT(3, 6)/4HSIN /
      DATATPLANT(1, 7)/4HDIFF/,TPLANT(2, 7)/4HUSED/,TPLANT(3, 7)/4H AIR/
      DATATPLANT(1, 8)/4HMECH/,TPLANT(2, 8)/4H AER/,TPLANT(3, 8)/4HATN /
      DATATPLANT(1, 9)/4HFLOC/,TPLANT(2, 9)/4HC -P/,TPLANT(3, 9)/4HRMRY/
      DATATPLANT(1,10)/4HSECY/,TPLANT(2,10)/4H SET/,TPLANT(3,10)/4HTLER/
      DATATPLANT(1,11)/4HRECI/,TPLANT(2,11)/4HRC P/,TPLANT(3,11)/4HMPNG/
      DATATPLANT(1,12)/4HCHLO/,TPLANT(2,12)/4HRNE /,TPLANT(3,12)/4HFEED/
      DATATPLANT(1,13)/4HCHLO/,TPLANT(2,13)/4HRNE /,TPLANT(3,13)/4HBASN/
      DATATPLANT(1,14)/4HMUL-/,TPLANT(2,14)/4HMED /,TPLANT(3,14)/4HFLTR/
      DATATPLANT(1,15)/4HRECI/,TPLANT(2,15)/4HRC P/,TPLANT(3,15)/4HMPNG/
      DATATPLANT(1,16)/4HGRAV/,TPLANT(2,16)/4H THI/,TPLANT(3,16)/4HCKNR/
      DATATPLANT(1,17)/4HFLOT/,TPLANT(2,17)/4H THI/,TPLANT(3,17)/4HCKNR/
      DATATPLANT(1,18)/4HANA /,TPLANT(2,18)/4HDIGE/,TPLANT(3,18)/4HSTN /
      DATATPLANT(1,19)/4HAER /,TPLANT(2,19)/4HDIGE/,TPLANT(3,19)/4HSTN /
      DATATPLANT(1,20)/4HSLGE/,TPLANT(2,20)/4H DRY/,TPLANT(3,20)/4H BED/
      DATATPLANT(1,21)/4HSLGE/,TPLANT(2,21)/4H HLD/,TPLANT(3,21)/4H TNK/
      DATATPLANT(1,22)/4HVACU/,TPLANT(2,22)/4HUM F/,TPLANT(3,22)/4HILTR/
      DATATPLANT(1,23)/4HCENT/,TPLANT(2,23)/4HRIFU/,TPLANT(3,23)/4HGE  /
      DATATPLANT(1,24)/4HMUL-/,TPLANT(2,24)/4HHRTH/,TPLANT(3,24)/4H INC/
      DATATPLANT(1,25)/4HFLUD/,TPLANT(2,25)/4H-BED/,TPLANT(3,25)/4H INC/
      DATATPLANT(1,26)/4HWAST/,TPLANT(2,26)/4HE PO/,TPLANT(3,26)/4HND  /
      DATATPLANT(1,27)/4HSLGE/,TPLANT(2,27)/4H LAG/,TPLANT(3,27)/4HOON /
      DATATPLANT(1,28)/4HRECA/,TPLANT(2,28)/4HRBON/,TPLANT(3,28)/4HATN1/
      DATATPLANT(1,29)/4HRECA/,TPLANT(2,29)/4HRBON/,TPLANT(3,29)/4HATN2/
      DATATPLANT(1,30)/4HTER /,TPLANT(2,30)/4HSETT/,TPLANT(3,30)/4HLER1/
      DATATPLANT(1,31)/4HTER /,TPLANT(2,31)/4HSETT/,TPLANT(3,31)/4HLER2/
      DATATPLANT(1,32)/4HALUM/,TPLANT(2,32)/4H FEE/,TPLANT(3,32)/4HDING/
      DATATPLANT(1,33)/4HFECL/,TPLANT(2,33)/4H FEE/,TPLANT(3,33)/4HDING/
      DATATPLANT(1,34)/4HLIME/,TPLANT(2,34)/4H FEE/,TPLANT(3,34)/4HDING/
      DATATPLANT(1,35)/4HPOLY/,TPLANT(2,35)/4H FEE/,TPLANT(3,35)/4HDING/
      DATATPLANT(1,36)/4HCO2 /,TPLANT(2,36)/4H FEE/,TPLANT(3,36)/4HDING/
      DATATPLANT(1,37)/4HNAAL/,TPLANT(2,37)/4H FEE/,TPLANT(3,37)/4HDING/
      DATATPLANT(1,38)/4HPCKL/,TPLANT(2,38)/4H FEE/,TPLANT(3,38)/4HDING/
      DATATPLANT(1,39)/4HNAOH/,TPLANT(2,39)/4H FEE/,TPLANT(3,39)/4HDING/
      DATATPLANT(1,40)/4HRECA/,TPLANT(2,40)/4HLCIN/,TPLANT(3,40)/4HATN /
      DATATPLANT(1,41)/4HFLOC/,TPLANT(2,41)/4HC -T/,TPLANT(3,41)/4HRTRY/
      DATATPLANT(1,42)/4HEXTR/,TPLANT(2,42)/4HA EX/,TPLANT(3,42)/4HTRA /
      DATATPLANT(1,43)/4HEXTR/,TPLANT(2,43)/4HA EX/,TPLANT(3,43)/4HTRA /
      DATATPLANT(1,44)/4HEXTR/,TPLANT(2,44)/4HA EX/,TPLANT(3,44)/4HTRA /
      DATATPLANT(1,45)/4HEXTR/,TPLANT(2,45)/4HA EX/,TPLANT(3,45)/4HTRA /
C        ASSUMED VALUES FOR PROCESS DESIGN VARIABLES
      DATA TPLANT(13, 1) /30./
      DATA TPLANT(13, 2) /0./
      DATA TPLANT(13, 3) /700./
      DATA TPLANT(13, 4) /4./
      DATA TPLANT(13, 5) /5./
      DATA TPLANT(13, 6) /6./
      DATA TPLANT(13, 7) /.05/
      DATA TPLANT(13, 8) /3.5/
      DATA TPLANT(13, 9) /0./
      DATA TPLANT(13,10) /700./
      DATA TPLANT(13,11) /30./
      DATA TPLANT(13,12) /8./
      DATA TPLANT(13,13) /15./
      DATA TPLANT(13,14) /0./
      DATA TPLANT(13,15) /15./
      DATA TPLANT(13,16) /20./
      DATA TPLANT(13,17) /2./
      DATA TPLANT(13,18) /15./
      DATA TPLANT(13,19) /15./
      DATA TPLANT(13,20) /2.3/
      DATA TPLANT(13,21) /4./
      DATA TPLANT(13,22) /4.5/
      DATA TPLANT(13,23) /.34/
      DATA TPLANT(13,24) /8./
      DATA TPLANT(13,25) /8./
      DATA TPLANT(13,26) /0./
      DATA TPLANT(13,27) /0./
      DATA TPLANT(13,28) /30./
      DATA TPLANT(13,29) /30./
      DATA TPLANT(13,30) /700./
      DATA TPLANT(13,31) /700./
      DATA TPLANT(13,32) /.03/
      DATA TPLANT(13,33) /.042/
      DATA TPLANT(13,34) /.01/
      DATA TPLANT(13,35) /1.5/
      DATA TPLANT(13,36) /.023/
      DATA TPLANT(13,37) /.12/
      DATA TPLANT(13,38) /.04/
      DATA TPLANT(13,39) /0./
      DATA TPLANT(13,40) /0./
      DATA TPLANT(13,41) /0./
      DATA TPLANT(13,42) /0./
      DATA TPLANT(13,43) /0./
      DATA TPLANT(13,44) /0./
      DATA TPLANT(13,45) /0./
C         SIZING PARAMETER UNITS USED FOR PRINTOUT
      DATA TPLANT(14,1) /4HMGD /, TPLANT(14,2) /4HMGD /
      DATA TPLANT(14,3) /4HTSF /, TPLANT(14,4) /4HGPM /
      DATA TPLANT(14,5) /4HTCF /, TPLANT(14,6) /4HTCF /
      DATA TPLANT(14,7) /4HTCFM/, TPLANT(14,8) /4H HP /
      DATA TPLANT(14,9) /4HMGD /, TPLANT(14,10) /4HTSF /
      DATA TPLANT(14,11) /4HMGD /, TPLANT(14,12) /4H#/D /
      DATA TPLANT(14,13) /4HTCF /, TPLANT(14,14) /4HMGD /
      DATA TPLANT(14,15) /4HMGD /, TPLANT(14,16) /4HTSF /
      DATA TPLANT(14,17) /4HSQFT/, TPLANT(14,18) /4HTCF /
      DATA TPLANT(14,19) /4HTCF /, TPLANT(14,20) /4HTSF /
      DATA TPLANT(14,21) /4HTCF /, TPLANT(14,22) /4HSQFT/
      DATA TPLANT(14,23) /4HGPM /, TPLANT(14,24) /4H#/H /
      DATA TPLANT(14,25) /4H#/D /, TPLANT(14,26) /4H    /
      DATA TPLANT(14,27) /4H    /, TPLANT(14,28) /4HTCF /
      DATA TPLANT(14,29) /4HTCF /, TPLANT(14,30) /4HTSF /
      DATA TPLANT(14,31) /4HTSF /, TPLANT(14,32) /4H#/D /
      DATA TPLANT(14,33) /4H#/D /, TPLANT(14,34) /4H#/D /
      DATA TPLANT(14,35) /4H#/D /, TPLANT(14,36) /4H#/D /
      DATA TPLANT(14,37) /4H#/D /, TPLANT(14,38) /4H#/D /
      DATA TPLANT(14,39) /4H#/D /, TPLANT(14,40) /4H    /
      DATA TPLANT(14,41) /4HMGD /, TPLANT(14,42) /4H    /
      DATA TPLANT(14,43) /4H    /, TPLANT(14,44) /4H    /
      DATA TPLANT(14,45) /4H    /
C         MINIMUM AND MAXIMUM VALUES FOR VALID RANGE FOR CONSTRUCTION EQ.
```

```
      DATA TPLANT(15,1) /.2/, TPLANT(16,1) /1000./
      DATA TPLANT(15,2) /1./, TPLANT(16,2) /200./
      DATA TPLANT(15,3) /1./, TPLANT(16,3) /200./
      DATA TPLANT(15,4) /30./, TPLANT(16,4) /5000./
      DATA TPLANT(15,5) /3./, TPLANT(16,5) /9000./
      DATA TPLANT(15,6) /3./, TPLANT(16,6) /4000./
      DATA TPLANT(15,7) /.02/, TPLANT(16,7) /200./
      DATA TPLANT(15,8) /20./, TPLANT(16,8) /5000./
      DATA TPLANT(15,9) /1./, TPLANT(16,9) /200./
      DATA TPLANT(15,10) /1./, TPLANT(16,10) /200./
      DATA TPLANT(15,11) /.5/, TPLANT(16,11) /300./
      DATA TPLANT(15,12) /20./, TPLANT(16,12) /8000./
      DATA TPLANT(15,13) /3./, TPLANT(16,13) /300./
      DATA TPLANT(15,14) /1./, TPLANT(16,14) /200./
      DATA TPLANT(15,15) /.5/, TPLANT(16,15) /300./
      DATA TPLANT(15,16) /.02/, TPLANT(16,16) /20./
      DATA TPLANT(15,17) /0./, TPLANT(16,17) /1.E10/
      DATA TPLANT(15,18) /30./, TPLANT(16,18) /6000./
      DATA TPLANT(15,19) /0./, TPLANT(16,19) /1.E10/
      DATA TPLANT(15,20) /7./, TPLANT(16,20) /4000./
      DATA TPLANT(15,21) /1./, TPLANT(16,21) /1000./
      DATA TPLANT(15,22) /80./, TPLANT(16,22) /6000./
      DATA TPLANT(15,23) /1.5/, TPLANT(16,23) /700./
      DATA TPLANT(15,24) /700./, TPLANT(16,24) /30000./
      DATA TPLANT(15,25) /0./, TPLANT(16,25) /1.E10/
      DATA TPLANT(15,26) /0./, TPLANT(16,26) /1.E10/
      DATA TPLANT(15,27) /30./, TPLANT(16,27) /30000./
      DATA TPLANT(15,28) /1./, TPLANT(16,28) /400./
      DATA TPLANT(15,29) /1./, TPLANT(16,29) /400./
      DATA TPLANT(15,30) /1./, TPLANT(16,30) /200./
      DATA TPLANT(15,31) /1./, TPLANT(16,31) /200./
      DATA TPLANT(15,32) /0./, TPLANT(16,32) /1.E10/
      DATA TPLANT(15,33) /0./, TPLANT(16,33) /1.E10/
      DATA TPLANT(15,34) /0./, TPLANT(16,34) /1.E10/
      DATA TPLANT(15,35) /0./, TPLANT(16,35) /1.E10/
      DATA TPLANT(15,36) /0./, TPLANT(16,36) /1.E10/
      DATA TPLANT(15,37) /0./, TPLANT(16,37) /1.E10/
      DATA TPLANT(15,38) /0./, TPLANT(16,38) /1.E10/
      DATA TPLANT(15,39) /0./, TPLANT(16,39) /1.E10/
      DATA TPLANT(15,40) /1./, TPLANT(16,40) /200./
      DATA TPLANT(15,41) /1./, TPLANT(16,41) /200./
      DATA TPLANT(15,42) /0./, TPLANT(16,42) /1.E10/
      DATA TPLANT(15,43) /0./, TPLANT(16,43) /1.E10/
      DATA TPLANT(15,44) /0./, TPLANT(16,44) /1.E10/
      DATA TPLANT(15,45) /0./, TPLANT(16,45) /1.E10/

      END
      SUBROUTINE BUILD
C
C        PURPOSE:
C           BUILD DETERMINES THE MAXIMUM SIZE OF THE NECESSARY
C           ADDITIONAL EQUIPMENT NEEDED FOR EACH PROCESS AND THE TIME
C           PERIOD WHEN ADDITIONAL EQUIPMENT IS FIRST NEEDED.
C
C        COMMON BLOCKS:
C           PRGCNT - PROGRAM CONTROL VARIABLES
C           TIME   - INFO ABOUT TIME HORIZON
C           TPLANT - CHARACTERISTICS OF THE TREATMENT PLANT PROCESSES
C           TRTCST - TREATMENT COSTS FOR EACH PROCESS FOR EACH TIME
C
C        CALLED BY:
C           TRTMNT - THE MAIN COSTING SUBROUTINE
C
C        AUTHOR:
C           DAVID A BARNES   19DEC72
C
C        -------------------------------------------------------------
      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP

      COMMON /TPLANT/ TPLANT(16,45)
     1 , RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHAER, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGOCN, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
     6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     8 , WVAR  , BPARM , BASE  , APVAR , PARMX , MINRV , MAXRV
     9 , MAXP

      INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
     1 , DIFAIR, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, RE2PMP
     2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
     3 , CENFUG, FBINC , WSPOND, SLGOCN, RECRB1, RECRB2, TERST1
     4 , TERST2, ALUMFS, FECLFS, POLYFS, CO2FS , PCKLFS, RECALC
     5 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     6 , WVAR  , BPARM , FLOCCT, BASE  , APVAR , PARMX

      COMMON /TRTCST/ OMHRS(45,20), MMHRS(45,20), TMS(45,20), CONCOS(45)
     1              , AMCOST(45), TPFADD(45)
```

```
      REAL MMHRS
      INTEGER TPFADD
C
C         ****************************************************************
C         ****************                                ****************
C         ****************    START EXECUTION             ****************
C         ****************                                ****************
C         ****************************************************************
C
1000  CONTINUE
C
C         COMPUTE ADDITIONAL SIZE NEEDED TO BE BUILT
C         FOR EVERY PROCESS
      DO 4000 IP = 1,MAXP
      IF (TP .LE. 1)  TPFADD(IP) = MAXTP + 1
      TPLANT(BPARM,IP) = 0.
      TPLANT(BASE,IP) = AMAX1(TPLANT(WOPARM,IP),TPLANT(PPARM,IP))
      B = TPLANT(WPARM,IP)
      IF (TPLANT(PPARM,IP) .GT. 0.)
     1    B = DIM(TPLANT(WPARM,IP),TPLANT(BASE,IP))
C
C         COMPUTE TIME PERIOD WHEN ADDITIONAL EQUIPMENT IS FIRST NEEDED
C         NOTE: USE 0.01 INSTEAD OF 0.0 BECAUSE OF ROUND OFF ERRORS
      IF ((B .GT. 0.01) .AND. (TP .LE. TPFADD(IP)))  TPFADD(IP) = TP
      IF (B .GT. TPLANT(BPARM,IP)) TPLANT(BPARM,IP) = B
4000  CONTINUE
C
C         END OF SUBROUTINE BUILD
      RETURN
      END
      SUBROUTINE CMMNTY
C
C        PURPOSE:
C           CMMNTY READS IN VALUES FOR THE VARIABLES WHICH DESCRIBE THE
C           COMMUNITY.  THESE INCLUDE SUCH AREAS AS: SEWERED POPULATION,
C           ENERGY-, TRANSPORTATION-COSTS, LIQUID AND SOLID
C           SINKS.
C
C        COMMON BLOCKS:
C           ENGCST  - DELIVERED COSTS OF ENERGY FORMS
C           INDSTY  - INFORMATION ABOUT INDUSTRIAL PHOSPHORUS EFFLUENTS
C           LBRCST  - COSTS OF LABOR (DIRECT AND INDIRECT)
C           LSINK   - CHARACTERISTICS OF LIQUID SINKS
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           SEWPOP  - THE SEWERED POPULATION
C           SSINK   - CHARACTERISTICS OF SOLID WASTE SINKS
C           TSCST   - TIME AND SPACE DIFFERENCE COSTS
C
C        CALLED BY:
C           SYSTEM
C
C        AUTHOR:
C           DAVID A BARNES   19DEC72
C
C        ----------------------------------------------------------------
      COMMON /ENGCST/ ELECOS, OILCOS, GASCOS

      COMMON /INDSTY/ INDSTY(3,20), LEGINP

      REAL INDSTY, LEGINP

      COMMON /LBRCST/ DHR, IDFRAC, GOVFF

      REAL IDFRAC

      COMMON /LSINK/ LIQSNK(3,20), LSNKCS(20), BESTLS(20)

      REAL LIQSNK, LSNKCS

      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /SEWPOP/ FNCTYP, SPOPIN(2,5), SEWPOP(20)
     1 , YEAR, SPOP, MAXPV

      INTEGER YEAR, SPOP, FNCTYP
```

```
FILE: CMMNTY   FORTRAN  P1                          INTERACTIVE DATA CORPORATION

      COMMON /SSINK/ TRNCST, SWASTE(20), SOLSNK(2,15), SSCOST(20)
     1              , BESTSS(20), CAP, DIST, MAXSS
      INTEGER BESTSS, CAP, DIST

      COMMON /TSCST/ CNSTRC, MATRLS

      REAL MATRLS

1010  FORMAT(1H0,/1X,'COMMUNITY CHARACTERISTICS')
3051  FORMAT(1H ,'ELECOS=')
3054  FORMAT(1H ,'ELECTRICITY COST ($/KWHR)')
3151  FORMAT(1H ,'OILCOS=')
3154  FORMAT(1H ,'OIL COST ($/GAL)')
3251  FORMAT(1H ,'GASCOS=')
3254  FORMAT(1H ,'GAS COST ($/CU.FT)')
4051  FORMAT(1H ,'DHR=')
4054  FORMAT(1H ,'DIRECT HOURLY LABOR RATE ($/HR)')
4151  FORMAT(1H ,'IDFRAC=')
4154  FORMAT(1H ,'INDIRECT FRACTION OF DIRECT LABOR')
5051  FORMAT(1H ,'FNCTYP=')
5054  FORMAT(1H ,'TYPE OF FUNCTION FOR SEWERED POPULATION GROWTH RATE')
5151  FORMAT(1H ,'SPOPIN(SPOP)=')
5154  FORMAT(1H ,'SEWERED POPULATION')
5251  FORMAT(1H ,'SPOPIN(YEAR)=')
5254  FORMAT(1H ,'YEAR OF GIVEN SEWERED POPULATION')
6051  FORMAT(1H ,'TRNCST=')
6054  FORMAT(1H ,'TRANSPORTATION COST OF SOLID WASTE ($/TON/MILE)')
6151  FORMAT(1H ,'SOLSNK(CAP)=')
6154  FORMAT(1H ,'CAPACITY OF SOLID SINK (TONS)')
6251  FORMAT(1H ,'SOLSNK(DIST)')
6254  FORMAT(1H ,'DISTANCE TO SOLID SINK (MILES)')
7051  FORMAT(1H ,'CNSTRC=')
7054  FORMAT(1H ,'CONSTRUCTION COST MULTIPLIER')
7151  FORMAT(1H ,'MATRLS=')
7154  FORMAT(1H ,'MATERIALS COST MULTIPLIER')

C        ***********************************************************
C        ****************                           ****************
C        ****************    START EXECUTION        ****************
C        ****************                           ****************
C        ***********************************************************
1000  CONTINUE
      PRINT 1010
3000  CONTINUE
C        READ IN DELIVERED COST OF ENERGY SUPPLIES
3050  PRINT 3051
3052  CALL READIN(FLOTE)
      GO TO (3053,3000,3055,3050,3056),  IGOTO
3053  PRINT 3054
      GO TO 3052
C        $.01/KWHR FROM REF. 6, P. 69
3055  ELECOS = .01
      GO TO 3057
3056  ELECOS = ANSWER
3057  CONTINUE
```

```
C         THE FOLLOWING ENERGY COSTS ARE NOT USED AT PRESENT
      GO TO 4000
3150  PRINT 3151
3152  CALL READIN(FLOTE)
      GO TO (3153,3000,3155,3150,3156),  IGOTO
3153  PRINT 3154
      GO TO 3152
C         NOT USED YET
3155  OILCOS = DUMMY
      GO TO 3157
3156  OILCOS = ANSWER
3157  CONTINUE
3250  PRINT 3251
3252  CALL READIN(FLOTE)
      GO TO (3253,3000,3255,3250,3256),  IGOTO
3253  PRINT 3254
      GO TO 3252
C         NOT USED YET
3255  GASCOS = DUMMY
      GO TO 3257
3256  GASCOS = ANSWER
3257  CONTINUE
4000  CONTINUE
C         READ IN LABOR COSTS
4050  PRINT 4051
4052  CALL READIN(FLOTE)
      GO TO (4053,4000,4055,4050,4056),  IGOTO
4053  PRINT 4054
      GO TO 4052
C         $3.95/MAN-HR FROM REF. 14.
4055  DHR = 3.95
      GO TO 4057
4056  DHR = ANSWER
4057  CONTINUE
4150  PRINT 4151
4152  CALL READIN(FLOTE)
      GO TO (4153,4000,4155,4150,4156),  IGOTO
4153  PRINT 4154
      GO TO 4152
C         .15 FROM REF. 6, P. 76
4155  IDFRAC = .15
      GO TO 4157
4156  IDFRAC = ANSWER
4157  CONTINUE
5000  CONTINUE
C         READ IN INFO FOR PRESENT AND FUTURE SEWERED POPULATION
5050  PRINT 5051
5052  CALL READIN(FIXED)
      GO TO (5053,5000,5055,5050,5056),  IGOTO
5053  PRINT 5054
      GO TO 5052
C         ASSUMED TYPE OF LINEAR WITH ASSUMED CONSTANT GROWTH RATE
5055  FNCTYP = 1
      GO TO 5057
5056  FNCTYP = IANSWR
```

```
5057  CONTINUE
C         SET NO OF POINTS TO BE READ IN FOR EACH TYPE OF CURVE
      IF(FNCTYP.EQ.1)GO TO 5110
      IF(FNCTYP.EQ.2.OR.FNCTYP.EQ.3)GO TO 5111
      IF(FNCTYP.EQ.4)GO TO 5112
      GO TO 5050
5110  LIM = 1
      GO TO 5113
5111  LIM = 2
      GO TO 5113
5112  LIM = 5
5113  CONTINUE
      LIM1 = 0
5114  LIM1 = LIM1 + 1
5150  PRINT 5151
5152  CALL READIN(FLOTE)
      GO TO (5153,5000,5155,5150,5156),  IGOTO
5153  PRINT 5154
      GO TO 5152
5156  SPOPIN(1,LIM1) = ANSWER
      GO TO 5157
5155  GO TO 5150
C         NO DEFAULT VALUE FOR SPOPIN
5157  CONTINUE
5250  PRINT 5251
5252  CALL READIN(FLOTE)
      GO TO (5253,5000,5255,5250,5256),  IGOTO
5253  PRINT 5254
      GO TO 5252
5255  GO TO 5250
C         NO DEFAULT VALUE FOR SPOPIN
5256  SPOPIN(2,LIM1) = ANSWER
5257  CONTINUE
C         CHECK NO OF ENTRIES
      IF (LIM.EQ.LIM1)  GO TO 5300
C         IF PIECE-WISE LINEAR ALLOW FEWER THAN 5 DATA POINTS
      IF (LIM1 .EQ. 5 .OR. ANSWER .EQ. 0.)  GO TO 5300
      GO TO 5114
5300  CONTINUE
6000  CONTINUE
6050  PRINT 6051
6052  CALL READIN(FLOTE)
      GO TO (6053,6000,6055,6050,6056),  IGOTO
6053  PRINT 6054
      GO TO 6052
C         5. $/TON-MILE FROM REF. 7
6055  TRNCST = 5.
      GO TO 6057
6056  TRNCST = ANSWER
6057  CONTINUE
      LIM1 = 0
6110  LIM1 = LIM1 + 1
6150  PRINT 6151
6152  CALL READIN(FLOTE)
      GO TO (6153,6000,6155,6150,6156),  IGOTO
```

```
 6153   PRINT 6154
        GO TO 6152
 C         ASSUMED INFINITE SINK CAPACITY
 6155   SOLSNK(CAP,LIM1) = 10.**10.
        GO TO 6157
 6156   IF (ANSWER .EQ. 99.)  GO TO 7000
        SOLSNK(CAP,LIM1) = ANSWER
 6157   CONTINUE
 6250   PRINT 6251
 6252   CALL READIN(FLOTE)
        GO TO (6253,6000,6255,6250,6256),  IGOTO
 6253   PRINT 6254
        GO TO 6252
 C         ASSUMED ZERO DISTANCE TO SINK
 6255   SOLSNK(DIST,LIM1) = 0.
        GO TO 6257
 6256   SOLSNK(DIST,LIM1) = ANSWER
 6257   CONTINUE
        IF (SOLSNK(CAP,LIM1) .NE. 0. .AND. LIM1 .LT. 15)  GO TO 6110
 7000   CONTINUE
 C         READ IN TIME AND LOCATION DIFFERENCE COSTS
 7050   PRINT 7051
 7052   CALL READIN(FLOTE)
        GO TO (7053,7000,7055,7050,7056),  IGOTO
 7053   PRINT 7054
        GO TO 7052
 C         1.714 = (WDQ-STP INDEX FOR MAY 72)/100. FROM REF. 8
 7055   CNSTRC = 1.714
        GO TO 7057
 7056   CNSTRC = ANSWER
 7057   CONTINUE
 7150   PRINT 7151
 7152   CALL READIN(FLOTE)
        GO TO (7153,7000,7155,7150,7156),  IGOTO
 7153   PRINT 7154
        GO TO 7152
 C         1.176 FROM REF. 9
 7155   MATRLS = 1.176
        GO TO 7157
 7156   MATRLS = ANSWER
 7157   CONTINUE
 C
 C         END OF SUBROUTINE CMMNTY
        RETURN
        END
```

```
      SUBROUTINE CONCST
C
C        PURPOSE:
C           CONCST COMPUTES CONSTRUCTION COSTS FOR EACH PROCESS
C           NOTE: FOR MOST PROCESSES THE EQUATIONS ARE FROM REF. 10
C
C        COMMON BLOCKS:
C           LBRCST - COST OF LABOR
C           SCHEME - INFO ABOUT LIQUID TREATMENT SCHEMES
C           TIME   - TIME HORIZON INFORMATION
C           TPLANT - CHARACTERISTICS OF TREATMENT PLANT PROCESSES
C           TRTCST - TREATMENT COSTS
C           TSCST  - TIME AND SPACE DIFFERENCE COSTS
C
C        CALLED BY:
C           TRTMNT - THE MAIN SIZING AND COSTING ROUTINE
C
C        REFERENCES:
C
C        AUTHOR:
C           DAVID A. BARNES 30 NOV 72
C
C        ------------------------------------------------------------
C
      COMMON /LBRCST/ DHR, IOFRAC, GOVFF

      REAL IOFRAC

      COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
     1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
     2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
     3 , ALTFMF, FCTFMF, ALFBAS, FCFBAS, L1FBAS, L2FBAS, NONE
     4 , EQUIP(45)

      INTEGER ELGBTY, EQUIP, SCHEME
      INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
     1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTFMF, FCTFMF, ALFBAS
     2 , FCFBAS
      REAL MINEFP

      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP

      COMMON /TPLANT/ TPLANT(16,45)
     1 , RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHAER, FLCCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FRINC , WSPOND, SLGOCN, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
     6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     8 , WVAR  , BPARM , BASE  , APVAR , PARMX , MINPV , MAXRV
     9 , MAXP
```

```
      INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
     1 , DIFAIR, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, RE2PMP
     2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
     3 , CENFUG, FBINC , WSPOND, SLGOCN, RECRB1, RECRB2, TERST1
     4 , TERST2, ALUMFS, FECLFS, POLYFS, CC2FS , PCKLFS, RECALC
     5 , PNAME , AMFATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     6 , WVAR  , BPARM , FLOCCT, BASE  , APVAR , PARMX

      COMMON /TRTCST/ OMHRS(45,20), MMHRS(45,20), TMS(45,20), CONCOS(45)
     1              , AMCOST(45), TPFADD(45)

      REAL MMHRS
      INTEGER TPFADD

      COMMON /TSCST/ CNSTRC, MATRLS

      REAL MATRLS

C
C        ************************************************************
C        *****************                            ***************
C        *****************    START EXECUTION         ***************
C        *****************                            ***************
C        ************************************************************
6000  CONTINUE
      DO 6005 IPROC = 1,MAXP
      CONCOS(IPROC) = 0.
6005  CONTINUE
C
C        RAW WASTEWATER PUMPING
6010  IF (TPLANT(BPARM,RWPUMP) .LE. 0.)  GO TO 6030
      X = ALOG(TPLANT(BPARM,RWPUMP))
      CONCOS(RWPUMP)=EXP(4.004828+.519499*X+.082262*X**2-.006492*X**3)
C
C        PRELIMINARY TREATMENT
6030  IF (TPLANT(BPARM,PRETRT) .LE. 0.)  GO TO 6050
      X = ALOG(TPLANT(BPARM,PRETRT))
      CONCOS(PRETRT)=EXP(3.259716+.619151*X)
C
C        PRIMARY SETTLER
6050  IF (TPLANT(BPARM,PRMSET) .LE. 0.)  GO TO 6070
      X = ALOG(TPLANT(BPARM,PRMSET))
      CONCOS(PRMSET)=EXP(3.716354+.389861*X+.08456*X**2-.004718*X**3)
C
C        PRIMARY SLUDGE PUMPING
6070  IF (TPLANT(BPARM,PSPUMP) .LE. 0.)  GO TO 6090
      X = ALOG(TPLANT(BPARM,PSPUMP))
      CONCOS(PSPUMP)=EXP(2.23733+.207678*X+.026479*X**2)
C
C        TRICKLING FILTER (SINGLE MEDIA)
6090  IF (TPLANT(BPARM,TRKFTR) .LE. 0.)  GO TO 6110
      X = ALOG(TPLANT(BPARM,TRKFTR))
      CONCOS(TRKFTR)=EXP(2.924951+.036285*X+.114673*X**2-.004587*X**3)
C
C        AERATION BASIN
```

```
6110  IF (TPLANT(BPARM,AERBSN) .LE. 0.)  GO TO 6130
      X = ALOG(TPLANT(BPARM,AERBSN))
      CONCOS(AERBSN)=EXP(2.41439+.175683*X+.084742*X**2-.00267*X**3)
C
C         DIFFUSED AIR SYSTEM
6130  IF (TPLANT(BPARM,DIFAIR) .LE. 0.)  GO TO 6150
      X = ALOG(TPLANT(BPARM,DIFAIR))
      CONCOS(DIFAIR)=EXP(4.145454+.633339*X+.031939*X**2-.002419*X**3)
C
C         MECHANICAL AERATION
6150  IF (TPLANT(BPARM,MCHAER) .LE. 0.)  GO TO 6170
      X = ALOG(TPLANT(BPARM,MCHAER))
      CONCOS(MCHAER)=EXP(2.8488-.223685*X+.142476*X**2-.005985*X**3)
C
C         FLOCCULATION BEFORE PRIMARY
6170  IF (TPLANT(BPARM,FLOCCP) .LE. 0.)  GO TO 6190
      X = ALOG(TPLANT(BPARM,FLOCCP))
C         EQUATION FROM REF. 12, P. 5-6, TABLE
      CONCOS(FLOCCP) = EXP(4.06044+.56209*X)
C
C         SECONDARY SETTLER
6190  IF (TPLANT(BPARM,SECSET) .LE. 0.)  GO TO 6210
      X = ALOG(TPLANT(BPARM,SECSET))
      CONCOS(SECSET)=EXP(3.716354+.389861*X+.08456*X**2-.004718*X**3)
C
C         RECIRCULATION PUMPING
6210  IF (TPLANT(BPARM,RE1PMP) .LE. 0.)  GO TO 6230
      X = ALOG(TPLANT(BPARM,RE1PMP))
      CONCOS(RE1PMP)=EXP(3.481553+.377485*X+.093349*X**2-.006222*X**3)
C
C         CHLORINE FEED SYSTEM
6230  IF (TPLANT(BPARM,CLFEED) .LE. 0.)  GO TO 6250
      X = ALOG(TPLANT(BPARM,CLFEED))
      CONCOS(CLFEED)=EXP(2.264294-.044271*X+.065029*X**2-.002536*X**3)
C
C         CHLORINATION CONTACT BASIN
6250  IF (TPLANT(BPARM,CLBASN) .LE. 0.)  GO TO 6270
      X = ALOG(TPLANT(BPARM,CLBASN))
      CONCOS(CLBASN)=EXP(2.048061+.521909*X-.002674*X**2+.004159*X**3)
C
C         MULTI-MEDIA FILTER
6270  IF (TPLANT(BPARM,MULFTR) .LE. 0.)  GO TO 6290
      X = ALOG(TPLANT(BPARM,MULFTR))
      CONCOS(MULFTR)=EXP(5.002242+.756791*X+.015051*X**2)
C
C         RECIRCULATION PUMPING
6290  IF (TPLANT(BPARM,RE2PMP) .LE. 0.)  GO TO 6310
      X = ALOG(TPLANT(BPARM,RE2PMP))
      CONCOS(RE2PMP)=EXP(3.481553+.377485*X+.093349*X**2-.006222*X**3)
C
C         GRAVITY THICKENER
6310  IF (TPLANT(BPARM,GRVTKN) .LE. 0.)  GO TO 6330
      X = ALOG(TPLANT(BPARM,GRVTKN))
      CONCOS(GRVTKN)=EXP(3.725092+.39769*X+.075742*X**2-.001979*X**3)
C
```

```
C          AIR FLOTATION THICKENER
6330  IF (TPLANT(BPARM,FLOTKN) .LE. 0.)  GO TO 6350
      X = ALOG(TPLANT(BPARM,FLOTKN))
      CONCOS(FLOTKN)=EXP(1.717538+.453735*X)
C
C          ANAEROBIC SLUDGE DIGESTION
6350  IF (TPLANT(BPARM,ANADIG) .LE. 0.)  GO TO 6370
      X = ALOG(TPLANT(BPARM,ANADIG))
      CONCOS(ANADIG)=EXP(7.679634-1.94968*X+.402610*X**2-.018211*X**3)
C
C          AEROBIC SLUDGE DIGESTION
6370  IF (TPLANT(BPARM,AERDIG) .LE. 0.)  GO TO 6390
      X = ALOG(TPLANT(BPARM,AERDIG))
C---       NO DATA FOR AERDIG
      CONCOS(AERDIG) = 0.
C
C          SLUDGE DRYING BED
6390  IF (TPLANT(BPARM,DRYBED) .LE. 0.)  GO TO 6410
      X = ALOG(TPLANT(BPARM,DRYBED))
      CONCOS(DRYBED)=EXP(1.971125+.083841*X+.146751*X**2-.007718*X**3)
C
C          SLUDGE HOLDING TANK
6410  IF (TPLANT(BPARM,SLDTNK) .LE. 0.)  GO TO 6430
      X = ALOG(TPLANT(BPARM,SLDTNK))
      CONCOS(SLDTNK)=EXP(2.627551+.48418*X+.000631*X**2+.002252*X**3)
C
C          VACUUM FILTER
6430  IF (TPLANT(BPARM,VACFTR) .LE. 0.)  GO TO 6450
      X = ALOG(TPLANT(BPARM,VACFTR))
      CONCOS(VACFTR)=EXP(3.238028+.194537*X+.038313*X**2)
C
C          CENTRIFUGE
6450  IF (TPLANT(BPARM,CENFUG) .LE. 0.)  GO TO 6470
      X = ALOG(TPLANT(BPARM,CENFUG))
      CONCOS(CENFUG)=EXP(4.528439+.049867*X+.053198*X**2)
C
C          MULTIPLE-HEARTH INCINERATION
6470  IF (TPLANT(BPARM,MHINC ) .LE. 0.)  GO TO 6490
      X = ALOG(TPLANT(BPARM,MHINC ))
      CONCOS(MHINC )=EXP(2.377364+.598986*X)
C
C          FLUIDIZED-BED INCINERATION
6490  IF (TPLANT(BPARM,FBINC ) .LE. 0.)  GO TO 6510
      X = ALOG(TPLANT(BPARM,FBINC ))
C---       NO DATA FOR FBINC
      CONCOS(FBINC ) = 0.
C
C          WASTE STABILIZATION POND
6510  IF (TPLANT(BPARM,WSPOND) .LE. 0.)  GO TO 6530
      X = ALOG(TPLANT(BPARM,WSPOND))
C---       NO DATA FOR WSPOND
      CONCOS(WSPOND) = 0.
C
C          SLUDGE LAGOON
6530  IF (TPLANT(BPARM,SLGOON) .LE. 0.)  GO TO 6550
```

```
      X = ALOG(TPLANT(BPARM,SLGCON))
      CONCOS(SLGCON) = EXP(.375449+.394996*X+.014726*X**2)
C
C        RE-CARBONIZATION
6550  IF (TPLANT(BPARM,RECRB1) .LE. 0.)  GO TO 6570
      X = ALOG(TPLANT(BPARM,RECRB1))
C        ASSUMED SAME AS AERATION BASIN, I.E., RECRB INCLUDES ONLY
C        THE BASIN STRUCTURE AND EVERYTHING ELSE IS INCLUDED IN CO2FS
      CONCOS(RECRB1)=EXP(2.41438+.175682*X+.084742*X**2-.00267*X**3)
      IF (EXP(X) .LT. 3.)  CONCOS(RECRB1) = 15.
C
C        RE-CARBONIZATION
6570  IF (TPLANT(BPARM,RECRB2) .LE. 0.)  GO TO 6590
      X = ALOG(TPLANT(BPARM,RECRB2))
C        ASSUMED SAME AS AERATION BASIN, I.E., RECRB INCLUDES ONLY
C        THE BASIN STRUCTURE AND EVERYTHING ELSE IS INCLUDED IN CO2FS
      CONCOS(RECRB2)=EXP(2.41438+.175682*X+.084742*X**2-.00267*X**3)
      IF (EXP(X) .LT. 3.)  CONCOS(RECRB2) = 15.
C
C        TERTIARY SETTLER
6590  IF (TPLANT(BPARM,TERST1) .LE. 0.)  GO TO 6610
      X = ALOG(TPLANT(BPARM,TERST1))
      CONCOS(TERST1)=EXP(3.716354+.389861*X+.08456*X**2-.004718*X**3)
C
C        TERTIARY SETTLER
6610  IF (TPLANT(BPARM,TERST2) .LE. 0.)  GO TO 6630
      X = ALOG(TPLANT(BPARM,TERST2))
      CONCOS(TERST2)=EXP(3.716354+.389861*X+.08456*X**2-.004718*X**3)
C
C        ALUM FEEDING AND STORAGE
6630  IF (TPLANT(BPARM,ALUMFS) .LE. 0.)  GO TO 6650
      X = ALOG(TPLANT(BPARM,ALUMFS))
C        IF AL USAGE IS LESS THAN 400 LBS/DAY,  CONCOS = A MINIMUM
      IF (EXP(X) .GT. 400.)  GO TO 6635
      CONCOS(ALUMFS) = 40.
      GO TO 6650
6635  CONCOS(ALUMFS)=EXP(11.95204-2.764643*X+.23226*X**2)
C
C        FERRIC CHLORIDE FEEDING AND STORAGE
6650  IF (TPLANT(BPARM,FECLFS) .LE. 0.)  GO TO 6670
      X = ALOG(TPLANT(BPARM,FECLFS))
C        IF FE USAGE IS LESS THAN 1000 LBS/DAY,  CONCOS = A MINIMUM
      IF (EXP(X) .GT. 1000.)  GO TO 6655
      CONCOS(FECLFS) = 40.
      GO TO 6670
6655  CONCOS(FECLFS)=EXP(15.44600-3.412989*X+.248351*X**2)
C
C        LIME FEEDING AND STORAGE
6670  IF (TPLANT(BPARM,LIMEFS) .LE. 0.)  GO TO 6690
      X = ALOG(TPLANT(BPARM,LIMEFS))
      CONCOS(LIMEFS)=EXP(-1.900487+.670797*X)
C
C        POLYMER FEEDING AND STORAGE
6690  IF (TPLANT(BPARM,POLYFS) .LE. 0.)  GO TO 6710
      X = ALOG(TPLANT(BPARM,POLYFS))
      CONCOS(PCLYFS)=EXP(1.263893+.494329*X+.045502*X**2)
C
C        CARBON DIOXIDE FEEDING AND STORAGE
6710  IF (TPLANT(BPARM,CO2FS ) .LE. 0.)  GO TO 6730
      X = ALOG(TPLANT(BPARM,CO2FS ))
C        ASSUMED SAME AS DIFFUSED AIR
      CONCOS(CO2FS )=EXP(4.145454+.633339*X+.031939*X**2-.002419*X**3)
C
C        SODIUM ALUMINATE FEEDING AND STORAGE
6730  IF (TPLANT(BPARM,NAALFS) .LE. 0.)  GO TO 6750
      X = ALOG(TPLANT(BPARM,NAALFS))
C        IF AL USAGE IS LESS THAN 400 LBS/DAY,  CONCOS = A MINIMUM
      IF (EXP(X) .GT. 400.)  GO TO 6735
      CONCOS(NAALFS) = .7*40.
      GO TO 6750
6735  CONCOS(NAALFS)=.7*EXP(11.95204-2.764643*X+.23226*X**2)
C
C        PICKLING LIQUOR FEEDING AND STORAGE
6750  IF (TPLANT(BPARM,PCKLFS) .LE. 0.)  GO TO 6770
      X = ALOG(TPLANT(BPARM,PCKLFS))
C        IF FE USAGE IS LESS THAN 1000 LBS/DAY,  CONCOS = A MINIMUM
      IF (EXP(X) .GT. 1000.)  GO TO 6755
      CONCOS(PCKLFS) = 40.
      GO TO 6770
6755  CONCOS(PCKLFS)=EXP(15.44600-3.412939*X+.248351*X**2)
C
C        SODIUM HYDROXIDE FEEDING AND STORAGE
6770  IF (TPLANT(BPARM,NAOHFS) .LE. 0.)  GO TO 6790
      X = ALOG(TPLANT(BPARM,NAOHFS))
C---     NO DATA FOR NAOHFS
      CONCOS(NAOHFS) = 0.
C
C     RECALCINATION
6790  IF (TPLANT(BPARM,RECALC) .LE. 0.)  GO TO 6810
      X = ALOG(TPLANT(BPARM,RECALC))
C        EQUATION FROM REF. 12, P. 17
C        1.2984 = WQO-STP INDEX FOR MAR 69
      CONCOS(RECALC) = 200.*X**.5 * 1.506/1.2984
C
C        FLOCCULATION BEFORE TERTIARY
6810  IF (TPLANT(BPARM,FLOCCT) .LE. 0.)  GO TO 6830
      X = ALOG(TPLANT(BPARM,FLOCCT))
C        EQUATION FROM REF. 12, P. 5-6, TABLE
      CONCOS(FLOCCT) = EXP(4.06044+.56209*X)
6830  CONTINUE
C
C        CONVERT NATIONAL AVERAGE JAN 71 DOLLARS TO PRESENT LOCAL DOLLAR
C        USING WQO-STP COST INDEX
C        COMPUTE PERIODIC AMORTIZED CONSTRUCTION COSTS FOR EACH
C        PROCESS
C
      DO 7500 IPROC = 1,MAXP
      IF (EQUIP(IPROC) .EQ. OFF)  GO TO 7500
      CONCOS(IPROC) = CONCOS(IPROC) * (CNSTRC/1.506) * (1.-GOVFF)
      RATE = TPLANT(AMRATE,IPROC)
      RTON = (1.+RATE)**TPLANT(AMLIFE,IPROC)
      CRF = (RATE*RTON)/(RTON-1.)
      AMCOST(IPROC) = CONCOS(IPROC)*CRF*TPSIZE
 7500 CONTINUE
C
C         END OF SUBROUTINE CONCST
      RETURN
      END
      SUBROUTINE DTGLIM
C
C        PURPOSE:
C           DTGLIM INITIALIZES THE INFLUENT-HALF OF IELIMT TO 'PINPS'
C           DTRGLIM READS IN THE PROPOSED LEGISLATIVE LIMITS ON THE
C           PHOSPHORUS CONTENT OF DETERGENTS AND THE IMPLEMENTATION
C           TIMES.  FOR EACH TIME PERIOD THE INFLUENT-HALF OF IELIMT
C           AND THE COSTS OF NON-PHOSPHATE SUBSTITUTES ARE COMPUTED.
C           NOTE:  DTGLIM ASSUMES THAT PYEAR WILL INCREASE EACH
C                  TIME IT IS READ IN.
C
C        COMMON BLOCKS:
C           DTRGNT -  CHARACTERISTICS OF DETERGENTS AND USAGE
C           IELIMT -  INFLUENT AND EFFLUENT LIMITS
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           LIQUID -  LIQUID INFLUENT INFORMATION
C           SEWPOP -  THE SEWERED POPULATION
C           TIME   - PARAMETERS OF THE TIME HORIZON
C
C        CALLED BY:
C           STRTGY -  CONTROL STRATEGY CALLING ROUTINE
C
C        AUTHOR:
C           DAVID A BARNES   11OCT77
C
C        ---------------------------------------------------------------
      COMMON /DTRGNT/ DTRGUS, PDRATO, PPRATO, DIFCOS, PRESPC
     1             , PDTRG , ENFCST,  PSUBCS(20), PCNTNT

      REAL LEGPC

      COMMON /IELIMT/ IELIMT(2,20)
     1 , INF, EFF

      REAL IELIMT
      INTEGER EFF

      COMMON /LIQUID/ ALKIPS, BODIPS, MLSSAR, NH3IAR, PINPS, QAVE
     1               , QPEAK, SSINPS, TBODAR

      REAL MLSSAR, NH3IAR

      COMMON /SEWPOP/ FNCTYP, SPCPIN(2,5), SEWPOP(20)
     1 , YEAR, SPOP, MAXPV

      INTEGER YEAR, SPOP, FNCTYP

      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP
1010  FORMAT(1H ,'DETERGENT RETRICTIONS')
1951  FORMAT(1H ,'RESTRICT?')
1954  FORMAT(1H ,'DO YOU WANT TO IMPLEMENT PHOSPHATE DETERGENT RESTRICTI
     1ONS? (YES OR NO)')
2051  FORMAT(1H ,'DIFCOS=')
2054  FORMAT (1H 'DIFFERENTIAL COST BETWEEN OLD & NEW DETERGENT ($/LB DT
     1RGNT)')
2151  FORMAT(1H ,'DTRGUS=')
2154  FORMAT(1H ,'ANNUAL PER CAPITA DETERGENT USE (LBS/CAP/YR)')
2251  FORMAT(1H ,'ENFCST=')
2254  FORMAT(1H ,'ANNUAL PER CAPITA ENFORCEMENT COST OF P BAN ($/CAP)')
2651  FORMAT(1H ,'PRESPC=')
2654  FORMAT(1H ,'PRESENT P CONCENTRATION IN DETERGENTS (RATIO)')
3051  FORMAT (1H ,'PCNTNT=')
3054  FORMAT (1H ,'PROPOSED LEGISLATED PHOSPHORUS CONTENT IN DETERGENTS
     1(FLOAT,FRAC)')
4051  FORMAT (1H ,'PYEAR=')
4054  FORMAT (1H ,'YEAR OF IMPLEMENTATION (FLOAT)')
3510  FORMAT (1H ,'PCNTNT IS TOO LARGE, RESUBMIT PCNTNT + PYEAR')

C         ****************************************************************
C         *****************                               *****************
C         *****************    START EXECUTION            *****************
C         *****************                               *****************
C         ****************************************************************
C
1000  CONTINUE
      PRINT 1010
      DO 1500 TP = 1,MAXTP
      IELIMT(INF,TP) = PINPS
      PSUBCS(TP) = 0.
1500  CONTINUE
C
C         ASK USER IF HE/SHE DESIRES TO TRY DETERGENT CONTROL STRATEGY
1900  CONTINUE
1950  PRINT 1951
1952  CALL READIN(ALPHA)
      GO TO (1953,1900,1955,1950,1956),  IGOTO
1953  PRINT 1954
      GO TO 1952
1955  IANSWR = NO
      GO TO 1957
1956  CONTINUE
1957  CONTINUE
      IF (IANSWR .EQ. YES)  GO TO 2000
      IF (IANSWR .EQ. NO)  RETURN
      GO TO 1900
2000  CONTINUE
C         READ IN DETERGENT INFORMATION
```

```
2050  PRINT 2051
2052  CALL READIN(FLOTE)
      GO TO (2053,2000,2055,2050,2056),  IGOTO
2053  PRINT 2054
      GO TO 2052
C        .02 $/LB FROM REF. 1.,P. 15 AND REF 11.
C        ASSUMING THAT 1 LB OF DETERGENT CONTAINS 0.4 LB OF PHOSPHATE OR
C        ITS SUBSTITUTE
2055  DIFCOS = .02
      GO TO 2057
2056  DIFCOS = ANSWER
2057  CONTINUE
2150  PRINT 2151
2152  CALL READIN(FLOTE)
      GO TO (2153,2000,2155,2150,2156),  IGOTO
2153  PRINT 2154
      GO TO 2152
C        27 LBS/CAPITA/YEAR FROM REF. 2
2155  DTRGUS = 27.
      GO TO 2157
2156  DTRGUS = ANSWER
2157  CONTINUE
2250  PRINT 2251
2252  CALL READIN(FLOTE)
      GO TO (2253,2000,2255,2250,2256),  IGOTO
2253  PRINT 2254
      GO TO 2252
C        $.40/CAPITA/YEAR FROM REF. 3
2255  ENFCST = .40
      GO TO 2257
2256  ENFCST = ANSWER
2257  CONTINUE
C        PDRATO = WEIGHT RATIO OF PHOSPHATE TO DETERGENT
C        .4 FROM REF. 4
      PDRATO = .4
C        PPRATO = WEIGHT RATIO OF PHOSPHORUS TO PHOSPHATE
C        .25 FROM REF. 5
      PPRATO = .25
2650  PRINT 2651
2652  CALL READIN(FLOTE)
      GO TO (2653,2000,2655,2650,2656),  IGOTO
2653  PRINT 2654
      GO TO 2652
C        NEGATIVE NUMBER WILL CAUSE PRESPC=PDRATO*PPRATO IN 'DTGLIM'
2655  PRESPC = -1.
      GO TO 2657
2656  PRESPC = ANSWER
2657  CONTINUE
C
C        READ IN LEGISLATED PHOSPHORUS CONTENT
3050  PRINT 3051
3052  CALL READIN(FLOTE)
      GO TO (3053,1000,3055,3050,3056),  IGOTO
3053  PRINT 3054
      GO TO 3052
```

```
3055  PCNTNT = 99.
      GO TO 3057
3056  PCNTNT = ANSWER
3057  CONTINUE
C        IF PCNTNT  = 99., THEN END OF LEGISLATION DATA SO RETURN
      IF( PCNTNT .EQ. 99.)  RETURN
C
C        READ IN IMPLEMENTATION YEAR ASSOCIATED WITH PCNTNT
4050  PRINT 4051
4052  CALL READIN(FLOTE)
      GO TO (4053,1000,4055,4050,4056),  IGOTO
4053  PRINT 4054
      GO TO 4052
4055  PYEAR = 0.
      GO TO 4057
4056  PYEAR = ANSWER
4057  CONTINUE
C
C        CHANGE YEAR OF IMPLEMENTATION TO A TIME PERIOD
      ICTP = (PYEAR - SPCPIN(YEAR,1))/TPSIZE
C
C            IF PRESENT P CONC. IS UNKNOWN, USE ASSUMED VALUE
      IF (PRESPC .LT. 0.)  PRESPC = PORATO*PPRATO
C
C        COMPUTE INFLUENT PHOSPHORUS RESULTING FROM DETERGENTS IN
C        (POUNDS/DAY)
      PDTRG = DTRGUS/365. * PRESPC * SEWPOP(1)
C
C        COMPUTE NEW P CONCENTRATION RESULTING FROM LEGISLATION
      PLEGRT  = (PRESPC - PCNTNT )/PRESPC
      IF (PLEGRT .LT. 0.)  PRINT 3510
      PINNEW = PINPS - PDTRG*PLEGRT/(QAVE*8.33)
C
C        COMPUTE THE ANNUAL PER CAPITA  COST OF NON-PHOSPHATE SUBSTITUTE
      PCOST = (DIFCOS*DTRGUS + ENFCST)*TPSIZE
C
C        FILL INFLUENT HALF OF IELIMT
C        AND STORE SUBSTITUTION COSTS FOR EACH TIME PERIOD
      DO 4500 TP = ICTP,MAXTP
      IELIMT(INF,TP) = PINNEW
      PSUBCS(TP) = PCOST * SEWPOP(TP)
4500  CONTINUE
C        READ IN NEXT LEGISLATED P CONTENT
      GO TO 3050
C
C        END OF SUBROUTINE DTGLIM
      END
      SUBROUTINE EFFLIM
C
C        PURPOSE:
C           EFFLIM READS IN THE PHOSPHORUS EFFLUENT LIMITS AND
C           CONSTRUCTS THE EFFLUENT-HALF OF IELIMT
C           NOTE: EFFLIM ASSUMES THAT 'EYEAR' WILL INCREASE
C           EACH TIME IT IS READ IN.
C
C        COMMON BLOCKS:
C           IELIMT - LIMITS ON INFLUENT/EFFLUENT PHOSPHORUS
C                    CONCENTRATIONS
C           LIQUID - LIQUID INFLUENT INFORMATION
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           SEWPOP - THE SEWERED POPULATION
C           TIME   - INFO ABOUT THE TIME HORIZON
C
C        CALLED BY:
C           STRTGY - THE CONTROL STRATEGY CALLING ROUTINE
C
C        AUTHOR:
C           DAVID A BARNES    11OCT72
C
C        ---------------------------------------------------------------
      COMMON /IELIMT/ IELIMT(2,20)
     1 , INF, EFF

      REAL IELIMT
      INTEGER EFF

      COMMON /LIQUID/ ALKIPS, BODIPS, MLSSAR, NH3IAR, PINPS, QAVE
     1                , QPEAK, SSINPS, TBODAR

      REAL MLSSAR, NH3IAR

      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /SEWPOP/ FNCTYP, SPCPIN(2,5), SEWPOP(20)
     1 , YEAR, SPCP, MAXPV

      INTEGER YEAR, SPCP, FNCTYP

      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP

 2051 FORMAT (1H ,'ELIMIT=')
 2054 FORMAT (1H ,'PROPOSED PHOSPHORUS EFFLUENT LIMIT (FLOAT,MG/L)')
```

```
3051  FORMAT (1H ,'EYEAR=')
3054  FORMAT (1H ,'YEAR OF LIMIT IMPLEMENTATION (FLOAT)')
C
C         ***********************************************************
C         *****************                         *****************
C         *****************     START EXECUTION     *****************
C         *****************                         *****************
C         ***********************************************************
C
1000  CONTINUE
      DO 1500 TP = 1,MAXTP
      IELIMT(EFF,TP) = PINPS
1500  CONTINUE
C
C         READ IN PROPOSED EFFLUENT LIMIT ON PHOSPHORUS
2050  PRINT 2051
2052  CALL READIN(FLOTE)
      GO TO (2053,1000,2055,2050,2056),  IGOTO
2053  PRINT 2054
      GO TO 2052
2055  ELIMIT = 99.
      GO TO 2057
2056  ELIMIT = ANSWER
2057  CONTINUE
C         RETURN IF ELIMIT = 99. = END OF DATA
      IF (ELIMIT .EQ. 99.)  RETURN
C
C         READ IN IMPLEMENTATION YEAR  ASSOCIATED WITH ELIMIT
3050  PRINT 3051
3052  CALL READIN(FLOTE)
      GO TO (3053,1000,3055,3050,3056),  IGOTO
3053  PRINT 3054
 .    GO TO 3052
3055  EYEAR = 0.
      GO TO 3057
3056  EYEAR = ANSWER
3057  CONTINUE
C
C         CHANGE YEAR OF IMPLEMENTATION TO A TIME PERIOD
      ICTP = (EYEAR - SPOPIN(YEAR,1))/TPSIZE
C
C         FILL EFFLUENT HALF OF IELIMT
      DO 4500 TP = ICTP,MAXTP
      IELIMT(EFF,TP) = ELIMIT
4500  CONTINUE
C
C         READ IN NEXT EFFLUENT LIMIT
      GO TO 2050
C         END OF SUBROUTINE EFFLIM
      END
      SUBROUTINE INDLIM
C
C        PURPOSE:
C           INDLIM READS IN LEGISLATED RESTRICTIONS ON INDUSTRIAL
C           PHOSPHORUS EFFLUENT.  THE CORRESPONDING CHANGES ARE THEN
C           MADE TO THE INFLUENT-HALF OF IELIMT.
C
C        COMMON BLOCKS:
C           INDSTY - INDUSTRIAL EFFLUENT LEVELS
C
C        CALLED BY:
C           STRTGY - THE CONTROL STRATEGY CALLING ROUTINE
C
C        AUTHOR:
C           DAVID A BARNES   11OCT72
C
C        ----------------------------------------------------------------
      COMMON /INDSTY/ INDSTY(3,20), LEGINP

      REAL INDSTY, LEGINP


C        ****************************************************************
C        ****************                                ****************
C        ****************    START EXECUTION             ****************
C        ****************                                ****************
C        ****************************************************************
C
C
C        END OF SUBROUTINE INDLIM
      RETURN
      END
      SUBROUTINE INTIME
C
C        PURPOSE:
C           INTIME READS IN A DESCRIPTION OF THE TIME HORIZON DESIRED.
C           IT THEN CALLS SPFNC TO COMPUTE THE SEWERED POPULATION FOR
C           EACH TIME PERIOD.
C           INTIME ALSO READS IN THE GOVERNMENT FINANCING FACTOR.
C
C        COMMON BLOCKS:
C           LBRCST - LABOR COSTS NAD GOVT. FINANCING FACTOR
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           TIME    - PARAMETERS OF TIME HORIZON
C
C        SUBROUTINES CALLED:
C           SPFNC  - COMPUTES SEWERED POPULATION FOR ALL TIME PERIODS
C
C        CALLED BY:
C           STRTGY  - CONTROL STRATEGY CALLING ROUTINE
C
C        AUTHOR:
C           DAVID A BARNES   15 MAR 73
C
C        ----------------------------------------------------------------

      COMMON /LBRCST/ DHP, IDFRAC, GOVFF

      REAL IDFRAC

      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP


2051  FORMAT (1H ,'NOYRS=')
2054  FORMAT (1H ,'NUMBER OF YEARS IN DESIRED TIME HORIZON (FIXED)')
3051  FORMAT (1H ,'TPSIZE=')
3054  FORMAT (1H ,'TIME PERIOD SIZE (FLOAT,YEARS)')
4251  FORMAT(1H ,'GOVFF=')
4254  FORMAT(1H ,'FRACTION OF CONSTRUCTION COSTS FINANCED BY FEDERAL AND
     1 STATE GOVERNMENTS')

C        ****************************************************************
C        ****************                                ****************
C        ****************    START EXECUTION             ****************
C        ****************                                ****************
```

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```
C       **************************************************************
C
1000  CONTINUE
C
C        READ IN NUMBER OF YEARS IN TIME HORIZON
2050  PRINT 2051
2052  CALL READIN(FIXED)
      GO TO (2053,1000,2055,2050,2056),  IGOTO
2053  PRINT 2054
      GO TO 2052
2055  NOYRS = 20
      GO TO 2057
2056  NOYRS = IANSWR
2057  CONTINUE
C
C        READ IN SIZE OF TIME PERIOD
3050  PRINT 3051
3052  CALL READIN(FLOTE)
      GO TO (3053,1000,3055,3050,3056),  IGOTO
3053  PRINT 3054
      GO TO 3052
3055  TPSIZE = 1.
      GO TO 3057
3056  TPSIZE = ANSWER
3057  CONTINUE
C
      MAXTP = FLOAT(NOYRS)/TPSIZE
C
C        COMPUTE SEWERED POPULATION FOR ALL TIME PERIODS
      CALL SPFNC
C        READ IN GOVERNMENT FINANCING FACTOR
4000  CONTINUE
4250  PRINT 4251
4252  CALL READIN(FLOTE)
      GO TO (4253,4000.4255,4250,4256),  IGOTO
4253  PRINT 4254
      GO TO 4252
C        0. MEANS 0 PERCENT HELP FROM FEDS
4255  GOVFF = 0.
      GO TO 4257
4256  GOVFF = ANSWER
4257  CONTINUE
C
C        END OF SUBROUTINE INTIME
      RETURN
      END
      SUBROUTINE LCHOSE
C
C        PURPOSE:
C           LCHOSE MARKS AS ELIGIBLE FOR CONSIDERATION THOSE LIQUID
C           TREATMENT SCHEMES WHICH WILL:
C           1. ACHIEVE THE DESIRED MINIMUM EFFLUENT PHOSPHORUS LEVEL
C           2. ACHIEVE A LEVEL CLOSE TO THAT DESIRED.
C
C        COMMON BLOCKS:
C           IELIMT - LIMITS ON INFLUENT/EFFLUENT PHOSPHORUS
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           LIQUID - LIQUID INFLUENT INFO
C           SCHEME - INFO ABOUT LIQUID TREATMENT SCHEMES
C           TIME   - INFO ABOUT TIME HORIZON
C           TPLANT - INFO ABOUT TREATMENT PLANT PROCESSES
C
C        CALLED BY:
C           REMOVE - THE MAIN PROGRAM
C
C        AUTHOR:
C           DAVID A BARNES   28 DEC 72
C
C        ------------------------------------------------------------
      COMMON /IELIMT/ IELIMT(2,20)
     1 , INF, EFF

      REAL IELIMT
      INTEGER EFF

      COMMON /LIQUID/ ALKIPS, BODIPS, MLSSAR, NH3IAR, PINPS, QAVE
     1               , QPEAK, SSINPS, TBODAR

      REAL MLSSAR, NH3IAR

      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
     1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
     2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
     3 , ALTEMF, FCTEMF, ALFBAS, FCFBAS, L1FBAS, L2FBAS, NONE
     4 , EQUIP(45)

      INTEGER ELGBTY, EQUIP, SCHEME
      INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
     1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTEMF, FCTEMF, ALFBAS
     2 , FCFBAS
      REAL MINEFP
      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP

      COMMON /TPLANT/ TPLANT(16,45)
     1 , FWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHAER, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGOON, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
     6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     8 , WVAR  , BPARM , BASE  , APVAR , PARMX , MINRV , MAXRV
     9 , MAXP

      INTEGER FWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
     1 , DIFAIR, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, RE2PMP
     2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
     3 , CENFUG, FBINC , WSPOND, SLGOON, RECRB1, RECRB2, TERST1
     4 , TERST2, ALUMFS, FECLFS, POLYFS, CO2FS , PCKLFS, RECALC
     5 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     6 , WVAR  , BPARM , FLOCCT, BASE  , APVAR , PARMX

C         ************************************************************
C         ****************                            ****************
C         ****************    START EXECUTION         ****************
C         ****************                            ****************
C         ************************************************************
C
1000  CONTINUE
      DO 1500 ISC = 1,MAXSCM
      ELGBTY(ISC) = OFF
1500  CONTINUE
      EFPMIN = 99.
C
C        FIND MINIMUM PHOSPHORUS EFFLUENT DESIRED
      DO 2000 TP = 1,MAXTP
      IF (IELIMT(EFF,TP) .LE. EFPMIN)  EFPMIN = IELIMT(EFF,TP)
2000  CONTINUE
      DELMIN = 99.
C
C        SEARCH ALL LIQUID TREATMENT SCHEMES FOR A MINIMUM PHOSPHORUS
C        EFFLUENT LEVEL ATTAINABILTY CLOSEST TO REQUIRED MIN P
      DO 3000 ISCH = 1,MAXSCM
      DELTA = MINEFP(ISCH) - EFPMIN
      IF ((DELTA .LE. 0.) .AND. (ABS(DELTA) .LE. DELMIN))
     1   DELMIN = ABS(DELTA)
3000  CONTINUE
C
C        MARK AS ELIGIBLE FOR CONSIDERATION THOSE LIQUID TREATMENT
C        SCHEMES WITH A MINIMUM DELTA
      DO 6000 ISCH = 1,MAXSCM
      DELTA = MINEFP(ISCH) - EFPMIN
      IF((DELTA .GT. 0.) .OR. (ABS(DELTA) .GT. DELMIN))  GO TO 6000
      ELGBTY(ISCH) = ON
C
C        CERTAIN SCHEMES USING LIME ARE NOT ELIGIBLE FOR CONSIDERATION
C        IF THE ALKALINITY IS LESS THAN SOME MINIMUM VALUE
      IF (ALKIPS .LT. 150. .AND.(ISCH .EQ. LIMEPS .OR. ISCH .EQ. LIMEFB
     1 ))  ELGBTY(ISCH) = OFF
      IF (ALKIPS .LT. 200. .AND. ISCH .EQ. LIFBAS)  ELGBTY(ISCH) = OFF
C        FERRIC CHLORIDE TERTIARY IS NOT TO BE CONSIDERED AT ALL
      IF (ISCH .EQ. FCFBAS)  ELGBTY(ISCH) = OFF
C
C        CERTAIN SCHEMES USING ALUM OR FERRIC CHLORIDE ARE INELIGIBLE
C        FOR CONSIDERATION IF THE ADDITION OF THESE SALTS, NECESSARY TO
C        ACHIEVE ADEQUATE PHOSPHORUS REMOVAL, WOULD DEPRESS THE
C        ALKALINITY BELOW SOME MINIMUM VALUE.
      IF (ISCH .NE. ALUMAB .AND. ISCH .NE. FECLAB .AND. ISCH .NE. ALABMF
     1 .AND. ISCH .NE. FCABMF)  GO TO 3190
      CATDSE = 3.5
      ALKRED = 2.
      IF (ISCH .EQ. FECLAB .OR. ISCH .EQ. FCABMF)  GO TO 3150
      CATDSE = 2.
      ALKRED = 4.2
 3150 CONTINUE
      DO 3170 IT = 1,MAXTP
      ALKIAR = ALKIPS - ALKRED*CATDSE*IELIMT(INF,IT)
      IF (ALKIAR .LT. 50.)  ELGBTY(ISCH) = OFF
 3170 CONTINUE
 3190 CONTINUE
C
C        IF SCHEME(J) CAN HAVE ALTERNATIVE EQUIVALENT PROCESSES, THEN
C        MAKE IT MATCH PRESENT PLANT CONFIGURATION AS CLOSE AS POSSIBLE.
      IF ((ISCH .LE. 8) .OR. ((ISCH .GE. 19) .AND. (ISCH .LE. 22)))
     1  GO TO 3300
      IF (ISCH .LE. 14)  GO TO 3500
      GO TO 6000
 3300 CONTINUE
C
C        GO TO END OF PROCESS DATA IN SCHEME J
      DO 3350 ILIQ = 1,25
      IF (SCHEME(ILIQ,ISCH) .LE. 0 )  GO TO 3400
 3350 CONTINUE
C
C        ADD ALTERNATIVE PROCESSES TO LIST OF REQUIRED EQUIPMENT
C
C        DETERMINE BIOLOGICAL TREATMENT METHOD, DEFAULT IS
C        ACTIVATED SLUDGE
 3400 CONTINUE
      SCHEME(ILIQ,ISCH) = AERBSN
      IF (TPLANT(PPARM,TRKFTR) .EQ. 0.)  GO TO 3430
      SCHEME(ILIQ,ISCH) = TRKFTR
      GO TO 6000
C
C        DETERMINE METHOD OF AERATION, DEFAULT IS MECHANICAL AERATION
 3430 ILIQ = ILIQ + 1
 3450 CONTINUE
```

```
      SCHEME(ILIQ,ISCH) = MCHAER
      IF (TPLANT(PPARM,DIFAIR) .NE. 0.)  SCHEME(ILIQ,ISCH) = DIFAIR
      GO TO 6000
3500  CONTINUE
C
C        GO TO END OF PROCESS DATA IN SCHEME J
      DO 3550 ILIQ = 1,25
      IF (SCHEME(ILIQ,ISCH) .LE. 0)  GO TO 3450
3550  CONTINUE
6000  CONTINUE
C
C        END OF SUBROUTINE LCHOSE
      RETURN
      END
      SUBROUTINE LSKCST
C
C       PURPOSE:
C          LSKCST CHOOSES A LIQUID SINK WITH A LARGE ENOUGH
C          ASSIMILATIVE PHOSPHORUS CAPACITY.  IT THEN COMPUTES THE
C          PUMP AND PIPE REQUIREMENTS.  AND THEN CALCULATES THE COST
C          OF THE SINK FOR EACH TIME PERIOD.
C
C       COMMON BLOCKS:
C          ENGCST - DELIVERED COSTS OF ENERGY FORMS
C          IELIMT - INFLUENT/EFFLUENT LIMITS
C          LIQUID - LIQUID INFLUENT INFORMATION
C          LSINK  - CHARACTERISTICS OF LIQUID SINKS
C          PRGCNT - PROGRAM CONTROL VARIABLES
C          SEWPOP - THE SEWERED POPULATION
C
C       CALLED BY:
C          REMOVE - THE MAIN PROGRAM
C
C       AUTHOR:
C          DAVID A BARNES   12OCT72
C
      COMMON /ENGCST/ ELECOS, OILCOS, GASCOS

      COMMON /IELIMT/ IELIMT(2,20)
     1 , INF, EFF

      REAL IELIMT
      INTEGER EFF

      COMMON /LIQUID/ ALKIPS, BODIPS, MLSSAR, NH3IAR, PINPS, QAVE
     1               , QPEAK, SSINPS, TBODAR

      REAL MLSSAR, NH3IAR

      COMMON /LSINK/ LIQSNK(3,20), LSNKCS(20), BESTLS(20)

      REAL LIQSNK, LSNKCS

      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /SEWPOP/ FNCTYP, SPOPIN(2,5), SEWPOP(20)
     1 , YEAR, SPOP, MAXPV

      INTEGER YEAR, SPOP, FNCTYP
```

```
C           *****************************************************************
C           *****************                               *****************
C           *****************    START EXECUTION            *****************
C           *****************                               *****************
C           *****************************************************************
C
C
C           END OF SUBROUTINE LSKCST
      RETURN
      END
      SUBROUTINE PLANT
C
C        PURPOSE:
C           PLANT READS IN VALUES OF VARIABLES WHICH DESCRIBE THE
C           SEWAGE TREATMENT PLANT.
C           NOTE: THE ASSUMED VALUES FOR 'APVAR', 'MINRV', AND 'MAXRV'
C           ARE FROM REF. 10.
C
C        COMMON BLOCKS:
C           CHMCST - CONTAINS DELIVERED COSTS OF CHEMICALS
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           TPLANT  - DESCRIPTION OF TREATMENT PLANT
C
C        CALLED BY:               .
C           SYSTEM
C
C        AUTHOR:
C           DAVID A BARNES   06OCT72
C
C        ---------------------------------------------------------------
C
      COMMON / CHMCST/ LIMECS, ALUMCS, POLYCS, FECLCS, NAALCS, PCKLCS
     1              , NAOHCS, CO2CS

      REAL LIMECS, NAALCS, NAOHCS

      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /TPLANT/ TPLANT(16,45)
     1 , RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHAER, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGOCN, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
     6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     8 , WVAR  , BPARM , BASE  , APVAR , PARMX , MINRV , MAXRV
     9 , MAXP

      INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
     1 , DIFAIR, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, RE2PMP
     2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
     3 , CENFUG, FBINC , WSPOND, SLGOCN, RECRB1, RECRB2, TERST1
     4 , TERST2, ALUMFS, FECLFS, POLYFS, CO2FS , PCKLFS, RECALC
     5 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     6 , WVAR  , BPARM , FLOCCT, BASE  , APVAR , PARMX
```

```
1010  FORMAT(1H0,'DESCRIPTION OF PRESENT TREATMENT PLANT'//
     1 ' SEE OPERATING MANUAL FOR DIMENSIONS OF PARAMETERS FOR EACH PROC
     2ESS')
2010  FORMAT(1H ,'TREATMENT PROCESS= ',3A4)
2151  FORMAT(1H ,'PPARM=')
2154  FORMAT(1H ,'PRESENT INDEPENDENT SIZING PARAMETER FOR COSTS')
1351  FORMAT(1H ,'AMRATE=')
1354  FORMAT(1H ,'AMORTIZATION RATE FOR ALL EQUIPMENT TO BE BUILT')
1551  FORMAT(1H ,'AMLIFE=')
1554  FORMAT(1H ,'AMORTIZATION LIFETIME FOR ALL EQUIPMENT TO BE BUILT')
2751  FORMAT(1H ,'PVAR=')
2754  FORMAT(1H ,'PRESENT DESIGN PARAMETER')

C        ***************************************************************
C        *****************                               *****************
C        *****************     START EXECUTION           *****************
C        *****************                               *****************
C        ***************************************************************
C
1000  CONTINUE
      PRINT 1010
C
C        READ IN AMORTIZATION RATE
1350  PRINT 1351
1352  CALL READIN(FLOTE)
      GO TO (1353,1000,1355,1350,1356),  IGOTO
1353  PRINT 1354
      GO TO 1352
1355  ARATE = .05
      GO TO 1357
1356  ARATE = ANSWER
1357  CONTINUE
C
C        READ IN AMORTIZATION LIFETIME
1550  PRINT 1551
1552  CALL READIN(FLOTE)
      GO TO (1553,1000,1555,1550,1556),  IGOTO
1553  PRINT 1554
      GO TO 1552
1555  ALIFE = 20.
      GO TO 1557
1556  ALIFE = ANSWER
1557  CONTINUE
      DO 1900 IPROC = 1,MAXP
      TPLANT(AMRATE,IPROC) = ARATE
      TPLANT(AMLIFE,IPROC) = ALIFE
      TPLANT(PVAR,IPROC) = TPLANT(APVAR,IPROC)
1900  CONTINUE
C
C        READ IN PARAMETERS FOR TREATMENT PROCESSES
      DO 3000 IPROC = 1,MAXP
      PRINT 2010, (TPLANT(J,IPROC),J=1,3)
C
C        READ IN PRESENT INDEPENDENT SIZING PARAMETER
2150  PRINT 2151
```

```
2152  CALL READIN(FLOTE)
      GO TO (2153,1000,2155,2150,2156),  IGOTO
2153  PRINT 2154
      GO TO 2152
2155  TPLANT(PPARM,IPROC) = 0.
      GO TO 2157
2156  IF (ANSWER .EQ. 99.)  GO TO 3500
      TPLANT(PPARM,IPROC) = ANSWER
2157  CONTINUE
      IF (TPLANT(PPARM,IPROC) .EQ. 0.)  GO TO 3000
C
C         READ IN PRESENT DESIGN PARAMETER FOR PROCESS IPROC
2750  PRINT 2751
2752  CALL READIN(FLOTE)
      GO TO (2753,1000,2755,2750,2756),  IGOTO
2753  PRINT 2754
      GO TO 2752
2755  TPLANT(PVAR,IPROC) = TPLANT(APVAR,IPROC)
      GO TO 2757
2756  TPLANT(PVAR,IPROC) = ANSWER
2757  CONTINUE
3000  CONTINUE
3500  CONTINUE
C
C         SET CHEMICAL COSTS IN 'CHMCST' EQUAL TO CHEMICAL COSTS
C         IN 'TPLANT'.  NOTE: THIS IS DONE BECAUSE THE STATEMENT
C         FUNCTIONS IN 'TRT1' AND 'TRT2' WILL NOT ALLOW ARRAYS.
      ALUMCS = TPLANT(PVAR,ALUMFS)
      CO2 CS = TPLANT(PVAR,CO2 FS)
      FECLCS = TPLANT(PVAR,FECLFS)
      LIMECS = TPLANT(PVAR,LIMEFS)
      NAALCS = TPLANT(PVAR,NAALFS)
      NAOHCS = TPLANT(PVAR,NAOHFS)
      PCKLCS = TPLANT(PVAR,PCKLFS)
      POLYCS = TPLANT(PVAR,POLYFS)
C
C         END OF SUBROUTINE PLANT
      RETURN
      END
      SUBROUTINE READIN(ITYPE)
C
C        PURPOSE:
C           READIN READS IN ANSWERS INPUT BY THE USER.  AFTER
C           EXAMINING THE VALUE TYPED IN, THE SUBROTUINE SETS *IGOTO*
C           SO THAT ON RETURN TO THE CALLING ROUTINE A CORRECT
C           BRANCH CAN OCCUR.  (USING *IGOTO* AND A COMPUTED GO TO
C           IS A CLUMSY WAY OF GETTING AROUND THE IMCOMPATIBILITIES
C           BETWEEN IBM AND CDC WITH RESPECT TO MULTIPLE RETURNS
C           FROM A SUBROUTINE.)
C           ITYPE HAS A VALUE OF:
C            FIXED = 1 = INTEGER VALUE IS EXPECTED
C            FLOTE = 2 = FLOATING POINT VALUE EXPECTED
C            ALPHA = 3 = ALPHANUMERIC EXPECTED
C           IGOTO CAN BE SET TO:
C            1 = PRINT FULL EXPLANATION OF QUESTION IF A *Q* WAS INPUT
C            2 = GO TO BEGINNING OF CALLING SUBROTUINE IF A *M* WAS
C                INPUT
C            3 = USE ASSUMED VALUE OF VARIABLE IF AN *A* WAS INPUT
C            4 = REPEAT BRIEF QUESTION BECAUSE INCORRECT VALUE
C                WAS INPUT
C            5 = CORRECT INPUT, RETURN AND CONTINUE PROCESSING
C
C        COMMON BLOCKS:
C           PRGCNT - PROGRAM CONTROL VARIABLES
C
C        CALLED BY:
C           CMMNTY - READS IN DESCRIPTION OF COMMUNITY
C           DTGLIM - READS IN RESTRICTIONS ON DETERGENT PHOSPHATES
C           EFFLIM - READS IN EFFLUENT RESTRICTIONS OF PLANT
C           INDLIM - READS IN INDUSTRIAL EFFLUENT RESTRICTIONS
C           INTIME - READS IN TIME HORIZON
C           PLANT  - READS IN DESCRIPTION OF TREATMENT PLANT
C           SEWAGE - READS IN DESCRIPTION OF SEWAGE
C
C        AUTHOR:
C           DAVID A BARNES   13OCT72
C
C        ------------------------------------------------------------
      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF


      DIMENSION ISTORE(10)
      REAL*8 INTYPE, M/1HM/, Q/1HQ/, A/1HA/
      LOGICAL*1 D(8)
C        D IS A DUMMY VARIABLE TO ALLOW US TO COUNT BYTES
      INTEGER*2 ITEMP, IDEC/1H./, IBLANK/1H /, NEG/1H-/
     1 , NUMS(10)/1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/
C        THE COMMON 'DUMMY' IS USED TO FORCE CONSECUTIVE STORAGE OF
C          THE THREE VARIABLES
      COMMON /DUMMY/ D, INTYPE, ITEMP

2010  FORMAT(A8)

C        ****************************************************************
C        *****************                              *****************
C        *****************    START EXECUTION           *****************
C        *****************                              *****************
C        ****************************************************************
C
C        READ IN INPUT VALUE IN *A* FORMAT
      READ (5,2010,END=5000) INTYPE
C        CHECK FOR 1ST AND ONLY CHARACTER EQUAL TO *Q*, *M*, OR *A*
      IF (INTYPE .NE. Q)  GO TO 2050
C        RETURN TO PRINT FULL EXPLANATION OF QUESTION
      IGOTO = 1
      RETURN
2050  IF (INTYPE .NE. M)  GO TO 2070
C        RETURN TO BEGINNING OF CALLING SUBROUTINE
      IGOTO = 2
      RETURN
2070  IF(INTYPE .NE. A)  GO TO 3000
C        RETURN TO USE ASSUMED VALUE OF VARIABLE
      IGOTO = 3
      RETURN
3000  CONTINUE
C        IF ALPHANUMERIC INPUT WAS EXPECTED, THEN RETURN
      IF (ITYPE .NE. ALPHA)  GO TO 4000
      ANSWER = INTYPE
      IGOTO = 5
      RETURN
4000  CONTINUE
C
C        CONVERT *A* FORMAT NUMBER READ IN TO AN INTEGER OR
C        FLOATING NUMBER
C
      NSIGN = 0
      IPLACE = 0
      ITEMP = IBLANK
C        DETERMINE NUMBER OF CHARACETERS TYPED IN, VALIDITY OF
C        CHARACTER, AND START CONVERSION
      DO 4200 I = 9,16
C         SHIFT BYTE TO LEFTMOST POSITION OF ITEMP
      D(17) = C(I)
C        CHECK FOR NEGATIVE SIGN
      IF (ITEMP .NE. NEG)  GO TO 4030
      NSIGN = 1
      GO TO 4200
4030  CONTINUE
C        CHECK FOR BLANK MEANING END OF NUMBER
      IF (ITEMP .EQ. IBLANK)  GO TO 4300
C        CHECK FOR DECIMAL POINT
```

```
      IF (ITEMP .NE. IDEC)  GO TO 4040
      IPLACE = I-8
      IF (ITYPE .EQ. FLOTE)  GO TO 4200
C         ERROR - DECIMAL POINT IN AN INTEGER
      IGOTO = 4
      RETURN
C          CHECK FOR VALID NUMERIC CHARACTER
4040  DO 4100 J = 1,10
      IF (ITEMP .EQ. NUMS(J))  GO TO 4150
4100  CONTINUE
C          ERROR - FOUND INVALID CHARACTER
      IGOTO = 4
      RETURN
4150  ISTORE(I-8) = J - 1
4200  CONTINUE
      MAXBYT = 8
      NUMCH = MAXBYT
      GO TO 4350
4300  NUMCH = I - 9
4350  CONTINUE
C          CONVERT NUMERIC CHARACTERS TO NUMERIC VALUE
      NUMBER = 0
      MAX = NUMCH
      IF (IPLACE .NE. 0)  MAX = NUMCH-1
      KOUNT = NSIGN
      N = 1
      IF (NSIGN .EQ. 1)  N=2
      DO 4400 K = N,NUMCH
C          SKIP OVER DECIMAL POINT
      IF (K .EQ. IPLACE) GO TO 4400
      KOUNT = KOUNT + 1
      NUMBER = NUMBER + ISTORE(K)*10**(MAX-KOUNT)
4400  CONTINUE
      IF (NSIGN .EQ. 1) NUMBER = NUMBER * (-1 * NSIGN)
      IF (ITYPE .EQ. FLOTE)  GO TO 4450
C          FIXED VALUE
      IANSWR = NUMBER
      IGOTO = 5
      RETURN
C          FLOATING POINT VALUE
4450  ANUM = FLOAT(NUMBER)
      IF (IPLACE .NE. 0)  ANUM = ANUM * 10.**(IPLACE-NUMCH)
      ANSWER = ANUM
      IGOTO = 5
      RETURN
5000  CONTINUE
C
C          NULL DATA TYPED IN
      IGOTO = 4
      RETURN
C          END OF SUBROUTINE READIN
      END
```

```
C
C        PURPOSE:
C           THIS IS THE MAIN PROGRAM. IT USES A COMPLETE DESCRIPTION OF
C           A COMMUNITY AND A DESIRED (INPUT BY USER) PHOSPHORUS CONTROL
C           STRATEGY TO COMPUTE THE COSTS OF DIFFERENT TREATMENT SCHEMES
C           WHICH ACHIEVE A GIVEN PHOSPHORUS EFFLUENT LEVEL. A REPORT ON
C           THE COSTS FOR EACH SCHEME IS THEN PRINTED.
C           NOTE 1: THIS PROGRAM WAS DESIGNED TO RUN ON AN IBM 360/67
C           TIME SHARING SYSTEM.  SPECIFICALLY, THAT OF, INTERACTIVE
C           DATA CORP., WALTHAM, MASS. (617-890-1234).
C           A CORE SIZE OF 288K BYTES WAS REQUIRED FOR EXECUTION.
C           NOTE 2: THE BASIC STUCTURE OF THE COST EQUATIONS WAS TAKEN
C           FROM REF. 10 AND FOR THIS WE ARE EXTREMELY GRATEFUL TO
C           RICHARD EILERS AND ROBERT SMITH OF EPA-CINCINNATI FOR THEIR
C           FINE WORK WHICH WE BUILT UPON.
C           NOTE 3: THE PROGRAM CORE AREA MUST BE SET TO ZERO BEFORE
C           LOADING THE OBJECT MODULE.  THIS IS NECESSARY BECAUSE
C           CERTAIN SUBROUTINES ASSUME THAT ZERO MARKS THE END OF DATA
C           INTO CERTAIN ARRAYS.
C
C        COMMON BLOCKS:
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           PRNTR  - CONTAINS PRINTOUT CONTROL VARIABLES
C           SCHEME - CHARACTERISTICS OF LIQUID TREATMENT SCHEMES
C
C        SUBROUTINES CALLED:
C           LCHOSE  - PICK LIQUID TREATMENT SCHEME
C           LSKCST  - COMPUTE COST OF FEASIBLE LIQUID SINK
C           REPORT  - PRINT SUMMARY OF COST INFO FOR SCHEME
C           SSKCST  - COMPUTE COSTS OF FEASIBLE SOLID SINKS
C           STRTGY  - INPUT CONTROL STRATEGY
C           SYSTEM  - INPUT DESCRIPTION OF COMMUNITY, SEWAGE, PLANT
C           TRTMNT  - COMPUTE COST OF LIQUID AND SLUDGE TREATMENT
C
C        REFERENCES:
C           1. MONOGRAPH NO. 9, 'ENVIRONMENT REPORTER', DOYLE, KATHLEEN
C              F., 20 AUG 71.
C
C           2. 'CHEMICAL HANDBOOK MANUAL OF CURRENT INDICATORS',
C              STANDFORD RESEARCH INSTITUTE, AUG 71.
C
C           3. PRIVATE COMMUNICATION WITH LARRY COX OF EPA-WASHINGTON,
C              D.C. ON 11 SEP 72.  HE SAID THAT SUFFOLK COUNTY, NY WAS
C              PLANNING ON $.40/CAPITA/YR.
C
C           4. 'NEWS RELEASE OF FRIDAY, 1 MAY 70', U.S. DEPT OF INTERIOR
C              FWQA.
C
C           5. 'REPORT TO OECD WORK GROUP ON DETERGENTS', BUNCH, ROBERT
C              L., SEP 71.
C
C           6. 'ESTIMATING COSTS AND MANPOWER REQUIREMENTS FOR
C              CONVENTIONAL WASTEWATER TREATMENT FACILITIES', PATTERSON,
C              W.L. AND BANKER, R.F. OF BLACK & VEATCH, CONSULTING
C              ENGINEERS, EPA REPORT NO. 17090 DAN.
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C
C          7. MYSELF
C
C          8. 'SEWAGE TREATMENT PALNT CONSTRUCTION COST INDEX', EPA-
C             OFFICE OF WATER PROGRAMS.
C
C          9. 'WHOLESALE PRICES AND PRICE INDICES - INDUSTRIAL
C              COMMODITIES', U.S. DEPT. OF LABOR.
C
C         10. 'COST2', A COMPUTER PROGRAM BY RICHARD EILERS OF
C              EPA-CINCINNATI, OHIO. 'COST2' COMPUTERIZES THE GRAPHS OF
C              REFERENCE 6.
C
C         11. PRIVATE COMMUNICATION WITH W.C. KRUMRI OF PROCTER
C              & GAMBLE, CINCINNATI, OHIO (513-562-2859) ON 6 SEP 72.
C              HE SAID THAT ANY NUMBER FROM -.05(FOR SODIUM CARBONATE)
C              TO +.26(FOR CITRIC ACID) WAS VALID BECAUSE NO ONE
C              SUBSTANCE HAS BEEN ACCEPTED AS A PHOSPHATE SUBSTITUTE.
C
C         12. 'PROCESS DESIGN MANUAL FOR PHOSPHORUS REMOVAL',
C              BLACK & VEATCH, CONSULTING ENGINEERS, EPA REPORT
C              NO. 17010-GNP.
C
C         13. 'COST AND PERFORMANCE ESTIMATES FOR TERTIARY WASTEWATER
C              TREATING PROCESSSES', SMITH, ROBERT AND MCMICHAEL, WALTER
C              F., EPA-CINCINNATI, OHIO, JUN 69.
C
C         14. 'EMPLOYMENT & EARNINGS STATISTICS - WATER, STEAM,
C              & SANITARY SYSTEMS (SIC 494-497)', U.S. DEPT. OF LABOR.
C
C         15. 'PRELIMINARY DESIGN AND SIMULATION OF CONVENTIONAL
C              WASTEWATER RENOVATION SYSTEMS USING THE DIGITAL
C              COMPUTER', ROBERT SMITH, EPA- CINCINNATI, MAR 68.
C              THIS REPORT PROVIDES A THEORECTICAL BACKGROUND FOR
C              REFERENCE 6.
C
C      NUMERIC CONSTANTS:
C               .020825 = POUNDS/GAL FOR LIQUID POLYMER
C               .029    = ASSUMED RATIO OF TRICKLING FILTER SLUDGE
C                         WASTING STREAM VOLUME TO INPUT VOLUME
C               .075    = POUNDS OF AIR/CUBIC FOOT
C               .123    = POUNDS OF CO2/ CUBIC FOOT
C               .125    = ENDOGENOUS RESPIRATION CONSTANT AT 20C
C               .232    = POUNDS OF O2/ POUND OF AIR
C               .4902   = POUNDS/GAL FOR LIQUID ALUM
C               .6      = ASSUMED FRACTION OF MLVSS WHICH ARE ACTIVE
C               .7      = ASSUMED RATIO OF MIXED LIQUOR VOLATILE
C                         SUSPENDED SOLIDS TO MLSSAR
C               .7457   = KILOWATTS/HORSEPOWER
C              1.506    = WQO-STP INDEX FOR JAN 71 NATIONAL AVERAGE $
C              2.27     = POUNDS OF FECL2/POUND OF FE
C              2.6      = POUNDS/GAL FOR FECL2
C              2.89     = POUND OF FECL3/ POUND OF FE
C              3.95     = POUNDS/GAL FOR FECL3
C              4.22     = POUNDS OF NAAL/POUND OF AL
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C            5.4        = POUNDS/GAL FOR ALUM
C            5.4        = (ASSUMED) POUNDS/GAL FOR NAAL
C            6.         = ASSUMED DEPTH OF TRICKLING FILTER MEDIA
C            7.48       = GALLONS/CUBIC FOOT FOR WATER
C            8.33       = POUNDS/GAL FOR WATER
C           11.         = POUNDS OF ALUM/POUND OF AL
C           24.         = HOURS/DAY
C           30.         = DAYS/MONTH
C           60.         = MINUTES/HOUR
C          180.         = ASSUMED CONCENTRATION OF SUSPENDED SOLIDS IN
C                         TRICKLING FILTER SLUDGE WASTING STREAM
C          365.         = DAYS/YEAR
C         1440.         = MINUTES/DAY
C         2000.         = POUNDS/TON
C        43560.         = SQUARE FEET/ACRE
C
C        AUTHOR:
C           DAVID A BARNES    09 FEB 73
C           RONALD ORNER
C           JBF SCIENTIFIC CORP.
C           2 RAY AVENUE
C           BURLINGTON, MA  01803
C           (617-273-0270)
C
C        ----------------------------------------------------------------
      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /PRNTR/ ISHORT, ISUPER, ISKIP, IPASS, ISELCT(5)

      COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
     1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
     2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
     3 , ALTFMF, FCTFMF, ALFBAS, FCFBAS, L1FBAS, L2FBAS, NONE
     4 , EQUIP(45)

      INTEGER ELGBTY, EQUIP, SCHEME
      INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
     1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTFMF, FCTFMF, ALFBAS
     2 , FCFBAS
      REAL MINEFP

 1010 FORMAT (1H0,'THIS IS THE PHOSPHORUS REMOVAL MODEL')
 6551 FORMAT (1H ,'SELECT?')
 6554 FORMAT (1H ,'DO YOU WISH A SELECTED LONG PRINTOUT? (YES OR NO)')
 6751 FORMAT (1H ,'SCHNO')
 6754 FORMAT (1H ,'NUMBER OF SCHEME TO BE LONG PRINTED (FIXED)')
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7851  FORMAT (1H0,'ANOTHER?')
7854  FORMAT (1H0,'DO YOU WISH TO TRY ANOTHER CONTROL STRATEGY (YES OR N
     1O)')
9010  FORMAT (1H0,'END OF PROGRAM')
C
C        **************************************************************
C        ***************                                 *****************
C        ****************    START EXECUTION             *****************
C        ***************                                 *****************
C        **************************************************************
C
1000  CONTINUE
C
C        PRINT STARTING MESSAGE
      PRINT 1010
C
C        READ IN COMPLETE DESCRIPTION OF THE COMMUNITY, SEWAGE, AND
C        TREATMENT PLANT
      CALL SYSTEM
C
C        READ IN CONTROL STRATEGY
2000  CALL STRTGY
      IPASS = 1
C
C        MARK ALL LIQUID TREATMENT SCHEMES WHICH WILL SATISFY THE
C        CONTROL STRATEGY AS ELIGIBLE FOR CONSIDERATION
3000  CALL LCHCSE
C
C        COMPUTE COSTS FOR ALL ELIGIBLE SCHEMES
      DO 7700 ISCHM = 1,MAXSCM
      IF (ELGBTY(ISCHM) .NE. ON)  GO TO 7700
C
C        COMPUTE LIQUID AND SLUDGE COSTS OF THIS ELIGIBLE TREATMENT
C        SCHEME FOR ALL TIME PERIODS
      CALL TRTMNT
C
C        COMPUTE COST OF LIQUID SINK FOR ALL TIME
      CALL LSKCST
C
C        COMPUTE COST OF SELECTED SOLID SINKS OVER ALL TIME
      CALL SSKCST
C
C        PRINT A SUMMARY OF TOTAL COSTS FOR THIS TREATMENT SCHEME
      CALL REPORT
C
C        END OF ELIGIBLE SCHEME LOOP
7700  CONTINUE
      IPASS = 2
C
C        ASK USER IF HE/SHE DESIRES A SELECTED LONG PRINTOUT
6500  CONTINUE
6550  PRINT 6551
6552  CALL READIN(ALPHA)
      GO TO (6553,1000,6555,6550,6556),  IGOTO
6553  PRINT 6554
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      GO TO 6552
6555  IANSWR = NO
      GO TO 6557
6556  CONTINUE
6557  CONTINUE
      IF (IANSWR .EQ. YES)  GO TO 6700
      IF (IANSWR .EQ. NO)  GO TO 7800
      GO TO 6500
C
C        SET UP SELECTED LONG PRINTOUT
6700  CONTINUE
      ISHORT = OFF
      ISUPER = OFF
      ISKIP = OFF
      DO 6600 I = 1,5
      ISELCT(I) = 0
6600  CONTINUE
      LIM = 0
6710  LIM = LIM + 1
6750  PRINT 6751
6752  CALL READIN(FIXED)
      GO TO (6753,1000,6755,6750,6756),  IGOTO
6753  PRINT 6754
      GO TO 6752
6755  ISELCT(LIM) = 0
      GO TO 6757
6756  ISELCT(LIM) = IANSWR
6757  CONTINUE
      IF (ISELCT(LIM) .NE. 99 .AND. LIM .LT. 5)  GO TO 6710
      GO TO 3000
C
C        ASK USER IF HE/SHE DESIRES TO TRY ANOTHER CONTROL STRATEGY
7800  CONTINUE
7850  PRINT 7851
7852  CALL READIN(ALPHA)
      GO TO (7853,1000,7855,7850,7856),  IGOTO
7853  PRINT 7854
      GO TO 7852
7855  IANSWR = NO
      GO TO 7857
7856  CONTINUE
7857  CONTINUE
      IF (IANSWR .EQ. YES)  GO TO 2000
      IF (IANSWR .EQ. NO)  GO TO 9000
      GO TO 7800
C
C        END OF PROGRAM
C        PRINT END MESSAGE
9000  CONTINUE
      PRINT 9010
      CALL EXIT
      END
      SUBROUTINE REPORT
C
C        PURPOSE:
C           REPORT PRINTS A SUMMARY OF THE COSTS ASSOCIATATED WITH
C           EACH ELIGIBLE TREATMENT SCHEME.
C
C        COMMON BLOCKS:
C           DTRGNT - DETERGENT INFORMATION
C           LBRCST - COST OF LABOR
C           LIQUID - INFO. ABOUT LIQUID INFLUENT
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           PRNTR  - CONTAINS PRINTOUT CONTROL VARIABLES
C           SCHEME - INFO ABOUT LIQUID TREATMENT SCHEMES
C           SEWPOP - THE SEWERED POPULATION
C           SLCHAR - SLUDGE, LIQUID CHARACTERISTICS
C           SLUDGE - SLUDGE INFO
C           SSINK  - SOLID SINK INFORMATION
C           TIME   - PARAMETERS OF TIME HORIZON
C           TPLANT - CHARACTERISTICS OF TREATMENT PROCESSES
C           TRTCST - TREATMENT COSTS
C
C        CALLED BY:
C           REMOVE - THE MAIN PROGRAM
C
C        AUTHOR:
C           DAVID A BARNES   26 JAN 73
C
C        ----------------------------------------------------------------
C
      COMMON /DTRGNT/ DTRGUS, PDRATO, PPRATO, DIFCOS, PRESPC
     1              , PDTRG , ENFCST,  PSUBCS(20), PCNTNT

      REAL LEGPC

      COMMON /LBRCST/ DHR, IDFRAC, GOVFF

      REAL IDFRAC

      COMMON /LIQUID/ ALKIPS, BODIPS, MLSSAR, NH3IAR, PINPS, QAVE
     1              , QPEAK, SSINPS, TBODAR

      REAL MLSSAR, NH3IAR

      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /PRNTR/ ISHORT, ISUPER, ISKIP, IPASS, ISELCT(5)
      COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
     1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
     2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
     3 , ALTEMF, FCTEMF, ALFBAS, FCFBAS, L1FBAS, L2FBAS, NONE
     4 , EQUIP(45)

      INTEGER ELGBTY, EQUIP, SCHEME
      INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
     1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTEMF, FCTEMF, ALFBAS
     2 , FCFBAS
      REAL MINEFP

      COMMON /SEWPOP/ FNCTYP, SPOPIN(2,5), SEWPOP(20)
     1 , YEAR, SPOP, MAXPV

      INTEGER YEAR, SPOP, FNCTYP

      COMMON /SLCHAR/    ADDSSR, ALKIAR, FCVFD , LBNVPS, LBNVSS
     1 , LBNVTS, LBVPS , LBVSS , LBVTS , LIMEPD, LMVFD , PALUM
     2 , PCO2  , PFECL , PNAAL , PNAOH , PCLYD , PPCKL , QPSLGE
     3 , QSSLGE, QTOTAL, QTSLGE, SRCAT , SRLIME, TLBNVS, TLBPS
     4 , TLBSLG, TLBSS , TLBTS , TLBVS , WOLBSS, WOPALM, WOPCO2
     5 , WOPFC , WOPLIM, WOPNAL, WOPNOH, WOPPLY, WOPPCK, WRCAT
     6 , PLIME , PYFTD , PYVFD , PPOLY , SRALF , SRCATA, WRALF
     7 , SRFEF , WRFEF , SRFEP , SRALP , WRALP , WRFEP , WRALA
     8 , WRFEA , AARATO, FFRATO, SRCATS, WRCATS, WRALS , WRFES
     9 , CO2D  , SRTLIM, TSETUC, LIMETD, BCDIAR, WOTLBS

      REAL       LBNVPS, LBNVSS, LBNVTS, LBVPS , LBVSS , LBVTS
     1 , LIMEPD, LMVFD , LIMETD

      COMMON /SLUDGE/ ASD   , FLOTUD, GRAVUD, HPDFT , HPDVF , PSETUD
     1               , PSRMVE, VFPSLG, VSANRM, VSARM

      COMMON /SSINK/ TRNCST, SWASTE(20), SOLSNK(2,15), SSCOST(20)
     1              , BESTSS(20), CAP, DIST, MAXSS
      INTEGER BESTSS, CAP, DIST

      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP

      COMMON /TPLANT/ TPLANT(16,45)
     1 , RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHAER, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGOCN, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
     6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     8 , WVAR  , PPARM , BASE  , APVAR , PARMX , MINRV , MAXRV
     9 , MAXP

      INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
     1 , DIFAIR, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, RE2PMP
     2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
     3 , CENFUG, FRINC , WSPOND, SLGOON, RECRB1, RECRB2, TERST1
     4 , TERST2, ALUMFS, FECLFS, POLYFS, CO2FS , PCKLFS, RECALC
     5 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     6 , WVAR  , PPARM , FLOCCT, BASE  , APVAR , PARMX

      COMMON /TRTCST/ OMHRS(45,20), MMHRS(45,20), TMS(45,20), CONCOS(45)
     1               , AMCOST(45), TPFADD(45)

      REAL MMHRS
      INTEGER TPFADD

      DIMENSION LBRAVE(45), SPAVE(45)
      REAL LBRAVE

1551  FORMAT (1H ,'SHORT?')
1554  FORMAT (1H ,'DO YOU WANT A SHORT PRINTOUT? (YES OR NO)')
1751  FORMAT (1H ,'SUPER SHORT?')
1754  FORMAT (1H ,'DO YOU WANT A SUPER SHORT PRINTOUT? (YES OR NO)')
2010  FORMAT (1H1,'LIQUID TREATMENT SCHEME = ',I5)
2020  FORMAT (1H ,'AMORTIZATION RATE =',F4.2,' AMORTIZATION LIFETIME ='
     1 ,F4.1)
2025  FORMAT (1H ,'FRACTION OF CONSTRUCTION COST FINANCED BY GOVERNMENT
     1 = ',F3.2)
2030  FORMAT (1H ,'BOD5 (INTO PRIMARY) = ',F4.0
     1 ,'  BOD5 (INTO SECONDARY) = ',F4.0)
2050  FORMAT (1H ,'SUSPENDED SOLIDS (INTO PRIMARY) = ',F5.0
     1 ,'  S.S. (INTO SECONDARY) = ',F5.0)
2130  FORMAT (1H0,//1X,'PROCESS NAME',4X,'CONSTRUCTION',9X,'SIZING',11X
     1 ,'AMORTIZED COST',6X,'YEAR PROCESS'/16X
     2 ,'COST(1000 $ )',6X,'PARAMETER',13X,'(1000 $ /TP)'
     3 , 6X,'FIRST NEEDED'/)
2150  FORMAT (1H ,3A4,7X,F9.3,5X,F10.3,2X,A4,10X,F9.3,9X,F6.1)
2170  FORMAT (1H ,/1X,'TOTALS =',10X,F11.3,28X,F11.3)
3010  FORMAT (1H0,///30X,'PERIODIC OPERATING COSTS'/)
3030  FORMAT (1H ,'PROCESS NAME',5X,'OPERATING MAN-HOURS',3X
     1 ,'MAINTAINANCE MAN-HOURS',8X,'MATERIAL & SUPPLY COST',7X
     A ,'LABOR COST'
     2 ,3X,'TOTAL O&M'/14X,2(5X,'(MAN-HOURS/TP)',5X),14X,'( $ /TP)',15X
     3 ,'(AVERAGE)',3X,'(1000$/TP)'/15X,2(2X,'AVE.',4X,'MAX.',4X,'MIN.',
     42X),6X,'AVE.',8X,'MAX.',8X,'MIN.',2X,'(1000$/TP)'/)
3050  FORMAT (1H ,3A4,2X,6(F6.0,2X),3(F10.2,2X),2(F10.3,2X))
3070  FORMAT (1H ,/1X,'TOTALS =',6X,6(F6.0,2X),3(F10.2,2X),2(F10.3,2X))
4010  FORMAT (1H0,///30X,'UNIT COST DATA'/27X,'(CENTS/1000 GALLONS)'/)
4030  FORMAT (1H ,'PROCESS NAME',3X,'AMORTIZATION',3X,'LABOR'
     1 ,3X,'MATERIAL & SUPPLY',3X,'TOTAL'/)
4050  FORMAT (1H ,3A4,5X,F5.2,7X,F5.2,9X,F5.2,10X,F5.2)
4070  FORMAT (1H ,/1X,'TOTALS =',9X,F5.2,7X,F5.2,9X,F5.2,10X,F5.2)
5010  FORMAT (1H0,///1X,'COSTS OF SUBTITUTES FOR PHOSPHATE DETERGENTS')
5030  FORMAT (1H ,'AVERAGE ($/TP) = ',F10.0/1X,'MAXIMUM ($/TP) = '
     1 ,F10.0/1X,'MINUMUM ($/TP) = ',F10.0/1X,'AVERAGE (CENTS/1000 GAL)
     2 = ',F5.2)
6010  FORMAT (1H0,///20X,'SOLID SINKS COSTS'/)
6030  FORMAT (1H ,'TIME',5X,'SINK',3X,'AMOUNT SOLIDS',8X,'COST'/
     1 1X,'PERIOD   USED        (TONS)',11X,'($/TP)')
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```
6050  FORMAT (1H ,I6,I7,6X,F10.2,3X,F10.2)
6070  FORMAT (1H ,/3X,'TOTALS =',9X,F10.2,3X,F10.2)
6090  FORMAT (1H ,/,1X,'UNIT COSTS FOR SOLID WASTE DISPOSAL (CENTS/1000
     1 GAL.) =',F10.2)
7020  FORMAT (1H ,'TOTAL UNIT COST (CENTS/1000 GAL) =',F5.1/)
C         ************************************************************
C         *****************                          *****************
C         *****************    START EXECUTION       *****************
C         *****************                          *****************
C         ************************************************************
C
1000  CONTINUE
C
C           IF THIS IS SECOND PASS THRU REPORT FOR A SELECTED
C           SCHEME, THEN EXECUTE LONG PRINTOUT
      IF (IPASS .EQ. 1)  GO TO 1200
      DO 1150 I = 1,5
      IF (ISELCT(I) .EQ. ISCHM)  GO TO 2000
1150  CONTINUE
      GO TO 9000
1200  IF (ISKIP .EQ. ON)  GO TO 1900
1500  ISHORT = OFF
      ISUPER = OFF
      ISKIP = ON
C
C           ASK USER OF HE/SHE DESIRES A SHORT PRINT OUT FOR ALL SCHEMES
1550  PRINT 1551
1552  CALL READIN(ALPHA)
      GO TO (1553,1000,1555,1550,1556),  IGOTO
1553  PRINT 1554
      GO TO 1552
1555  IANSWR = NO
      GO TO 1557
1556  CONTINUE
1557  CONTINUE
      IF (IANSWR .EQ. YES)  GO TO 1605
      IF (IANSWR .EQ. NO)  GO TO 1900
      GO TO 1500
C
C           SET UP CORRECT TYPE OF PRINT OUT
1605  ISHORT = ON
C
C           ASK USER IF HE/SHE DESIRES A SUPER SHORT PRINTOUT
1750  PRINT 1751
1752  CALL READIN(ALPHA)
      GO TO (1753,1000,1755,1750,1756),  IGOTO
1753  PRINT 1754
      GO TO 1752
1755  IANSWR = NO
      GO TO 1757
1756  CONTINUE
1757  CONTINUE
      IF (IANSWR .EQ. YES)  GO TO 1805
      IF (IANSWR .EQ. NO)  GO TO 1900
      GO TO 1500
C
C        SET UP CORRECT TYPE OF PRINTOUT
1805  ISUPER = ON
1900  CONTINUE
2000  CONTINUE
C
C        PRINT SCHEME NAME, AMORTIZATION RATE, AMORTIZATION LIFETIME
      PRINT 2010, ISCHM
      IF (ISUPER .EQ. ON)  GO TO 2100
      PRINT 2020, TPLANT(AMRATE,1), TPLANT(AMLIFE,1)
      PRINT 2025, GCVFF
C        IF SCHEME IS CHEMICALS TO PRIMARY PRINT BOD5 AND SS
      IF (ISCHM .GT. 8)  GO TO 2100
      PRINT 2030, BODIPS, BODIAR
      SSINS = SSINPS - (SSINPS*PSRMVE+ADDSSR)
      PRINT 2050, SSINPS, SSINS
2100  CONTINUE
C
C     PRINT CONSTRUCTION COSTS
      IF (ISUPER .EQ. OFF)  PRINT 2130
      TOTCON = 0.
      TOTAMC = 0.
      DO 2900 IPROC = 1,MAXP
      IF (EQUIP(IPROC) .EQ. OFF)  GO TO 2900
      TOTCON = TOTCON + CONCOS(IPROC)
      TOTAMC = TOTAMC + AMCOST(IPROC)
      YRFADD = TPFADD(IPROC)*TPSIZE + SPOPIN(YEAR,1)
      IF (ISHORT .EQ.  OFF)
     1 PRINT 2150, (TPLANT(J,IPROC),J=1,3), CONCOS(IPROC)
     2 , TPLANT(BPARM,IPROC), TPLANT(PARMX,IPROC), AMCOST(IPROC)
     3 , YRFADD
2900  CONTINUE
      IF (ISUPER .EQ. OFF)
     1  PRINT 2170, TOTCON, TOTAMC
3000  CONTINUE
C
C        PRINT PERIODIC OPERATING COSTS
      IF (ISUPER .EQ. ON)  GO TO 3100
      PRINT 3010
      PRINT 3030
C
C        ZERO COLUMN TOTALS
3100  CONTINUE
      CTOPAV = 0.
      CTOPMX = 0.
      CTOPMN = 0.
      CTAMAV = 0.
      CTAMMX = 0.
      CTAMMN = 0.
      CTSPAV = 0.
      CTSPMX = 0.
      CTSPMN = 0.
      CTLBAV = 0.
      CTAVRT = 0.
      DO 3900 IPROC = 1,MAXP
      IF (EQUIP(IPROC) .EQ. OFF)  GO TO 3900
      OP = 0.
      UP = 0.
      OPMAX = -1.
      OPMIN = 1.E10
      AM = 0.
      AMMAX = -1.
      AMMIN = 1.E10
      SP = 0.
      SPMAX = -1.
      SPMIN = 1.E10
C
C        TOTAL UP MAN-HOURS AND COSTS
      DO 3800 TP = 1,MAXTP
      OP = OP + AMAX1(OMHRS(IPROC,TP),0.)
      AM = AM + AMAX1(MMHRS(IPROC,TP),0.)
      SP = SP + AMAX1(TMS  (IPROC,TP),0.)
      OPMAX = AMAX1(OPMAX,OMHRS(IPROC,TP))
      AMMAX = AMAX1(AMMAX,MMHRS(IPROC,TP))
      SPMAX = AMAX1(SPMAX,TMS  (IPROC,TP))
      OPMIN = AMIN1(OPMIN,OMHRS(IPROC,TP))
      AMMIN = AMIN1(AMMIN,MMHRS(IPROC,TP))
      SPMIN = AMIN1(SPMIN,TMS  (IPROC,TP))
3800  CONTINUE
C
C        COMPUTE AVERAGE PERIODIC COSTS
      OPAVE = OP/MAXTP
      AMAVE = AM/MAXTP
      SPAVE(IPROC) = SP/MAXTP
      LBRAVE(IPROC) = ((OPAVE+AMAVE)*DHR*(1.+IDFRAC))/1000.
      ROWTOT = LBRAVE(IPROC) + SPAVE(IPROC)/1000.
C
C        COMPUTE COLUMN TOTALS
      CTOPAV = CTOPAV + OPAVE
      CTOPMX = CTOPMX + OPMAX
      CTOPMN = CTOPMN + OPMIN
      CTAMAV = CTAMAV + AMAVE
      CTAMMX = CTAMMX + AMMAX
      CTAMMN = CTAMMN + AMMIN
      CTSPAV = CTSPAV + SPAVE(IPROC)
      CTSPMX = CTSPMX + SPMAX
      CTSPMN = CTSPMN + SPMIN
      CTLBAV = CTLBAV + LBRAVE(IPROC)
      CTAVRT = CTAVRT + ROWTOT
      IF (ISHORT .EQ. OFF)
     1 PRINT 3050, (TPLANT(J,IPROC),J=1,3), OPAVE, OPMAX, OPMIN
     2 , AMAVE, AMMAX, AMMIN
     3 , SPAVE(IPROC), SPMAX, SPMIN, LBRAVE(IPROC), ROWTOT
3900  CONTINUE
      IF (ISUPER .EQ. OFF)
     1 PRINT 3070, CTOPAV, CTOPMX, CTOPMN, CTAMAV, CTAMMX, CTAMMN
     2 , CTSPAV, CTSPMX, CTSPMN, CTLBAV, CTAVRT
4000  CONTINUE
C
```

```
C          PRINT UNIT COSTS
      IF (ISUPER .EQ. ON)  GO TO 4100
      PRINT 4010
      PRINT 4030
4100  CONTINUE
      TPOP = 0.
      DO 4300 TP = 1,MAXTP
      TPOP = TPOP + SEWPOP(TP)
4300  CONTINUE
      POPAVE = TPOP/MAXTP
      FLWAVE = (GAVE*POPAVE/SEWPOP(1))*1000.
      CTUAMC = 0.
      CTULBR = 0.
      CTUMSP = 0.
      CTRT = 0.
      DO 4900 IPROC = 1,MAXP
      IF (EQUIP(IPROC) .EQ. OFF)  GO TO 4900
      A = 0.
      DO 4800 TP = 1,MAXTP
      IF (TP .GE. TPEADD(IPROC)) A = A + AMCOST(IPROC)
4800  CONTINUE
      A = A/MAXTP
      UAMC = ((A*1000./(365.*TPSIZE))/FLWAVE)*100.
      ULBR = ((LBRAVE(IPROC)*1000./(365.*TPSIZE))/FLWAVE)*100.
      UMSP = ((SPAVE(IPROC)/(365.*TPSIZE))/FLWAVE)*100.
      ROWTOT = UAMC + ULBR + UMSP
      CTUAMC = CTUAMC + UAMC
      CTULBR = CTULBR + ULBR
      CTUMSP = CTUMSP + UMSP
      CTRT = CTRT + ROWTOT
      IF (ISHORT .EQ. OFF)
     1 PRINT 4050, (TPLANT(J,IPROC),J=1,3), UAMC, ULBR, UMSP, ROWTOT
4900  CONTINUE
      IF (ISUPER .EQ. OFF)
     1 PRINT 4070, CTUAMC, CTULBR, CTUMSP, CTRT
5000  CONTINUE
C
C          PRINT COSTS OF SUBTITUTES FOR PHOSPHATE DETERGENTS
      P = 0.
      PMAX = -1.
      PMIN = 1.E10
      DO 5500 TP = 1,MAXTP
      P = P + PSUBCS(TP)
      PMAX = AMAX1(PMAX,PSUBCS(TP))
      PMIN = AMIN1(PMIN,PSUBCS(TP))
5500  CONTINUE
      IF (P .LE. 0.)  GO TO 5900
      PAVE = P/MAXTP
      UP = ((PAVE/(365.*TPSIZE))/FLWAVE)*100.
      IF (ISUPER .EQ. ON)  GO TO 5900
      PRINT 5010
      PRINT 5030, PAVE, PMAX, PMIN, UP
5900  CONTINUE
C
6000  CONTINUE
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C
C          PRINT COSTS OF SOLID SINKS
      IF (ISUPER .EQ. ON)  GO TO 6100
      PRINT 6010
      PRINT 6030
 6100 CONTINUE
      CTSSCS = 0.
      CTSWST = 0.
      DO 6500 TP = 1,MAXTP
C          USE 1. INSTEAD OF 0. BECAUSE OF ROUND-OFF
      IF (SWASTE(TP) .LE. 1.)  GO TO 6500
      CTSSCS = CTSSCS + SSCOST(TP)
      CTSWST = CTSWST + SWASTE(TP)
      IF (ISHORT .EQ. OFF)
     1 PRINT 6050, TP, BESTSS(TP), SWASTE(TP), SSCOST(TP)
 6500 CONTINUE
      USSCS = CTSSCS/((TPOP/SEWPOP(1))*QAVE*1000.*365.*TPSIZE)*100.
      IF (ISUPER .EQ. ON)  GO TO 6900
      PRINT 6070, CTSWST, CTSSCS
      PRINT 6090, USSCS
 6900 CONTINUE
C
C          PRINT SINGLE NUMBER FOR SUPER SHORT PRINTOUT
 7000 CONTINUE
      TOTAL = CTRT + UP + USSCS
      PRINT 7020, TOTAL
 7900 CONTINUE
C
C          END OF SUBROUTINE REPORT
 9000 CONTINUE
      RETURN
      END
      SUBROUTINE SCHOSE
C
C        PURPOSE:
C           SCHOSE PICKS THE SLUDGE HANDLING PROCESSES (EQUIPMENT) WHICH
C           ARE BOTH:
C           1. NECESSARY FOR A PARTICULAR LIQUID TREATMENT SCHEME
C           2. CONFORM MOST CLOSELY WITH THE PRESENT PLANT CONFIGURATION
C           SCHOSE ALSO CONSTRUCTS A COMPLETE LIST OF NECESSARY
C           EQUIPMENT FOR THIS SCHEME
C
C        COMMON BLOCKS:
C           PRGCNT - PROGRAM CONTROL VARIABLES
C           SCHEME - REQUIRED LIQUID HANDLING EQUIPMENT
C           SLGSCM - REQUIRED SLUDGE HANDLING EQUIPMENT
C           TPLANT - CHARACTERISTICS OF TREATMENT PLANT PROCESSES
C
C        CALLED BY:
C           TRTMNT - THE MAIN COSTING SUBROUTINE
C
C        AUTHOR:
C           DAVID A BARNES   26 DEC 72
C
C        -----------------------------------------------------------------
      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
     1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
     2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
     3 , ALTFMF, FCTFMF, ALFBAS, FCFBAS, L1FBAS, L2FBAS, NONE
     4 , EQUIP(45)

      INTEGER ELGBTY, EQUIP, SCHEME
      INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
     1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTFMF, FCTFMF, ALFBAS
     2 , FCFBAS
      REAL MINEFP

      COMMON /SLGSCM/ SLGSCM(20)
      INTEGER SLGSCM

      COMMON /TPLANT/ TPLANT(16,45)
     1 , FMPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHAER, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGDCN, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
     6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME  , AMRATE, AMLIFE, PPARM  , PVAR   , WOPARM, WPARM
     8 , WVAR   , BPARM , BASE   , APVAR  , PARMX  , MINRV  , MAXRV
     9 , MAXP

      INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
     1 , DIFAIR, FLCCCP, SECSET, RE1PMP, CLFEED, CLBASN, RE2PMP
     2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
     3 , CENFUG, FBINC , WSPOND, SLGDCN, RECRB1, RECRB2, TERST1
     4 , TERST2, ALUMFS, FECLFS, POLYFS, CC2FS , PCKLFS, RECALC
     5 , PNAME  , AMRATE, AMLIFE, PPARM  , PVAR   , WOPARM, WPARM
     6 , WVAR   , PPARM , FLOCCT, BASE   , APVAR  , PARMX

      DIMENSION SAVNEG(45)

C          *************************************************************
C          ****************                             ****************
C          ****************     START EXECUTION         ****************
C          ****************                             ****************
C          *************************************************************
C
1000  CONTINUE
C
C          RESTORE NEGATIVE PPARMS IF THEY HAVE BEEN SAVED FROM BEFORE
      IF (ISK .NE. ON)  GO TO 1900
      DO 1500 IPROC = 1,MAXP
      TPLANT(PPARM,IPROC) = SAVNEG(IPROC)
1500  CONTINUE
1900  CONTINUE
      I = 0
C
C          CHOOSE THICKENER, DEFAULT IS GRAVITY THICKENER
      I = I + 1
      SLGSCM(I) = GRVTKN
      IF (TPLANT(PPARM,FLOTKN) .EQ. 0.)  GO TO 2100
      I = I + 1
      SLGSCM(I) = FLOTKN
2100  CONTINUE
C
C          CHOOSE DIGESTER, DEFAULT IS NONE
      I = I + 1
      SLGSCM(I) = 0
      IF (TPLANT(PPARM,AERDIG) .NE. 0.)  SLGSCM(I) = AERDIG
      IF (TPLANT(PPARM,ANADIG) .NE. 0.)  SLGSCM(I) = ANADIG
C
C          CHOOSE DEWATERER, DEFAULT IS VACUUM FILTER
      I = I + 1
      SLGSCM(I) = VACFTR
      IF (TPLANT(PPARM,DRYBED) .NE. 0.)  SLGSCM(I) = DRYBED
      IF (TPLANT(PPARM,CENFUG) .NE. 0.)  SLGSCM(I) = CENFUG
C          ADD SLUDGE HOLDING TANK FOR VACUUM FILTER AND CENTRIFUGE
      IF (SLGSCM(I) .EQ. DRYBED)  GO TO 2300
      I = I + 1
      SLGSCM(I) = SLDTNK
C          ADD FECL AND LIME FEEDING AND STORAGE FOR VACUUM FILTER
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      IF (SLGSCM(I-1) .EQ. CENFUG)  GO TO 2200
      I = I+1
      SLGSCM(I) = LIMEFS
      I = I+1
      SLGSCM(I) = FECLFS
C
C        CHOOSE INCINERATOR , DEFAULT IS NONE
 2200 CONTINUE
      I = I + 1
      SLGSCM(I) = 0
      IF (TPLANT(PPARM,FBINC ) .NE. 0.)  SLGSCM(I) = FBINC
      IF (TPLANT(PPARM,MHINC ) .NE. 0.)  SLGSCM(I) = MHINC
C
C        CHOOSE WASTE STABILIZATION POND, DEFAULT IS NONE
 2300 CONTINUE
      I = I + 1
      SLGSCM(I) = 0
      IF (TPLANT(PPARM,WSPOND) .NE. 0.)  SLGSCM(I) = WSPOND
C
C        CHOOSE SLUDGE LAGOON, DEFAULT IS NONE
      I = I + 1
      SLGSCM(I) = 0
      IF (TPLANT(PPARM,SLGOON) .NE. 0.)  SLGSCM(I) = SLGOON
C
C        IF LIQUID TREATMENT SCHEME IS A TERTIARY LIME SCHEME,
C        THEN USE RECALCINATION
      I = I + 1
      SLGSCM(I) = 0
      IF ((ISCHM .EQ. L1FBAS) .OR. (ISCHM .EQ. L2FBAS))
     1  SLGSCM(I) = RECALC
C
C        CONSTRUCT COMPLETE LIST OF NECESSARY EQUIPMENT FOR THIS
C        STRATEGY
C
 3000 CONTINUE
C
C        INITIALIZE WHOLE LIST TO 'OFF'
      DO 3050 IPROC = 1,MAXP
      EQUIP(IPROC) = OFF
 3050 CONTINUE
C
C        TURN 'ON' REQUIRED PROCESSES COMMON TO ALL SCHEMES
      EQUIP(RWPUMP) = ON
      EQUIP(PRETRT) = ON
      EQUIP(PRMSET) = ON
      EQUIP(PSPUMP) = ON
      EQUIP(SECSET) = ON
      EQUIP(RE1PMP) = ON
      EQUIP(CLFEED) = ON
      EQUIP(CLBASN) = ON
C
C        FILL EQUIP WITH REQUIRED LIQUID PROCESSES
      DO 3100 ILIQ = 1,25
      IF (SCHEME(ILIQ,ISCHM) .NE. 0)  EQUIP(SCHEME(ILIQ,ISCHM)) = ON
 3100 CONTINUE
```

```
C
C           FILL EQUIP WITH NECESSARY SLUDGE PROCESSES
      DO 3200 ISLG = 1,I
      IF (SLGSCM(ISLG) .NE. 0)  EQUIP(SLGSCM(ISLG)) = ON
 3200 CONTINUE
C
C           IF PPARM IS NEGATIVE, THEN CHANGE IT TO ZERO
      ISK = ON
      DO 3500 IPROC = 1,MAXP
      SAVNEG(IPROC) = TPLANT(PPARM,IPROC)
      IF (TPLANT(PPARM,IPROC) .LT. 0.)  TPLANT(PPARM,IPROC) = 0.
 3500 CONTINUE
C
C           END OF SUBROUTINE SCHOSE
      RETURN
      END
      SUBROUTINE SEWAGE
C
C        PURPOSE:
C           SEWAGE READS IN VALUES FOR VARIABLES WHICH DESCRIBE THE
C           CHARACTERISTICS OF THE SEWAGE.
C           NOTE: ASSUMED VALUES OF VARIABLES ARE FROM REF. 10.
C
C        COMMON BLOCKS:
C           LIQUID  - LIQUID INFLUENT INFORMATION
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           SLUDGE  - SLUDGE INFORMATION
C
C        CALLED BY:
C           SYSTEM
C
C        AUTHOR:
C           DAVID A BARNES   27 DEC 72
C
C        ----------------------------------------------------------------
      COMMON /LIQUID/ ALKIPS, BODIPS, MLSSAR, NH3IAR, PINPS, QAVE
     1              ,  QPEAK, SSINPS, TBODAR

      REAL MLSSAR, NH3IAR

      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /SLUDGE/ ASD   , FLOTUD, GRAVUD, HPDFT , HPDVF , PSETUD
     1              , PSRMVE, VFPSLG, VSANRM, VSARM , TSETUD

 1010 FORMAT(1H0,'SEWAGE CHARACTERISTICS')
 1051 FORMAT(1H ,'ALKIPS=')
 1054 FORMAT(1H ,'ALKILINITY CONC. INTO PRIMARY SETTLR (CACO3 MG/L)')
 1151 FORMAT(1H ,'BODIPS=')
 1154 FORMAT(1H ,'BOD5 CONC. INTO PRIMARY SETTLER (MG/L)')
 1251 FORMAT(1H ,'MLSSAR=')
 1254 FORMAT(1H ,'MIXED LIQUOR SUSPENDED SOLIDS IN AER. PROC. (MG/L)')
 1351 FORMAT(1H ,'NH3IAR=')
 1354 FORMAT(1H ,'NH3 CONC. INTO AERATION PROC (MG/L)')
 1451 FORMAT(1H ,'PINPS=')
 1454 FORMAT(1H ,'PHOSPHORUS CONC. INTO PRIMARY SETTLER (MG/L)')
 1551 FORMAT(1H ,'QAVE=')
 1554 FORMAT(1H ,'PRESENT AVERAGE DAILY FLOW (MGD)')
 1751 FORMAT(1H ,'QPEAK=')
 1754 FORMAT(1H ,'PRESENT PEAK DIURNAL FLOW (MGD)')
 1851 FORMAT(1H ,'SSINPS=')
 1854 FORMAT(1H ,'SUSPENDED SOLIDS CONC. INTO PRIMARY SETTLER (MG/L)')
 1951 FORMAT(1H ,'TBODAR=')
```

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1954  FORMAT(1H ,'TOTAL CHANGE IN BOD5 ACROSS AERATION PROCESS (FRACTION
     1 REMOVED)')
2051  FORMAT(1H ,'ASD=')
2054  FORMAT(1H ,'ACTIVATED SLUDGE DENSITY (FRACTION)')
2151  FORMAT(1H ,'FLOTUD=')
2154  FORMAT(1H ,'FLOTATION THICKNER UNDERFLOW SLUDGE DENSITY (FRAC)')
2251  FORMAT(1H ,'GRAVUD=')
2254  FORMAT(1H ,'GRAVITY THICKNER UNDERFLOW SLUDGE DENSITY (FRAC)')
2351  FORMAT(1H ,'PSETUD=')
2354  FORMAT(1H ,'PRIMARY SETTLER UNDERFLOW SLUDGE DENSITY (FRAC)')
2451  FORMAT(1H ,'VFPSLG=')
2454  FORMAT(1H ,'VOLATILE FRACTION FOR PRIMARY SLUDGE')
2551  FORMAT(1H ,'VSANRM=')
2554  FORMAT(1H ,'VOLATILE SLUDGE REMAINING AFTER ANAEROBIC DIGESTION (F
     1RACTION)')
2651  FORMAT(1H ,'VSARM=')
2654  FORMAT(1H ,'VOLATILE SLUDGE REMAINING AFTER AEROBIC DIGESTION (FRA
     1CTION)')
2751  FORMAT(1H ,'HPDFT=')
2754  FORMAT(1H ,'MAX. ALLOWABLE OPERATING HRS/DAY FOR FLOTATION THICKEN
     1ER')
2851  FORMAT(1H ,'HPDVF=')
2854  FORMAT(1H ,'MAX. ALLOWABLE OPERATING HRS/DAY FOR VACUUM FILTER')
2951  FORMAT(1H ,'PSRMVF=')
2954  FORMAT(1H ,'REMOVAL OF SUSPENDED SOLIDS IN PRIMARY SETTLER(FRAC)')

C        ****************************************************************
C        *****************                               ****************
C        *****************    START EXECUTION            ****************
C        *****************                               ****************
C        ****************************************************************
C
1000  CONTINUE
      PRINT 1010
C        READ IN LIQUID INFLUENT CHARACTERISTICS
1050  PRINT 1051
1052  CALL READIN(FLOTE)
      GO TO (1053,1000,1055,1050,1056), IGOTO
1053  PRINT 1054
      GO TO 1052
1055  ALKIPS =  201.
      GO TO 1057
1056  ALKIPS = ANSWER
1057  CONTINUE
1150  PRINT 1151
1152  CALL READIN(FLOTE)
      GO TO (1153,1000,1155,1150,1156),  IGOTO
1153  PRINT 1154
      GO TO 1152
1155  BODIPS = 200.
      GO TO 1157
1156  BODIPS = ANSWER
1157  CONTINUE
1250  PRINT 1251
1252  CALL READIN(FLOTE)
```

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      GO TO (1253,1000,1255,1250,1256),  IGOTO
1253  PRINT 1254
      GO TO 1252
1255  MLSSAR = 2000.
      GO TO 1257
1256  MLSSAR = ANSWER
1257  CONTINUE
1350  PRINT 1351
1352  CALL READIN(FLOTE)
      GO TO (1353,1000,1355,1350,1356),  IGOTO
1353  PRINT 1354
      GO TO 1352
1355  NH3IAR = 0.
      GO TO 1357
1356  NH3IAR = ANSWER
1357  CONTINUE
1450  PRINT 1451
1452  CALL READIN(FLOTE)
      GO TO (1453,1000,1455,1450,1456),  IGOTO
1453  PRINT 1454
      GO TO 1452
1455  PINPS = 10.
      GO TO 1457
1456  PINPS = ANSWER
1457  CONTINUE
1550  PRINT 1551
1552  CALL READIN(FLOTE)
      GO TO (1553,1000,1555,1550,1556),  IGOTO
1553  PRINT 1554
      GO TO 1552
1555  QAVE = 10.
      GO TO 1557
1556  QAVE = ANSWER
1557  CONTINUE
1750  PRINT 1751
1752  CALL READIN(FLOTE)
      GO TO (1753,1000,1755,1750,1756),  IGOTO
1753  PRINT 1754
      GO TO 1752
1755  QPEAK = 19.
      GO TO 1757
1756  QPEAK = ANSWER
1757  CONTINUE
1850  PRINT 1851
1852  CALL READIN(FLOTE)
      GO TO (1853,1000,1855,1850,1856),  IGOTO
1853  PRINT 1854
      GO TO 1852
1855  SSINPS = 200.
      GO TO 1857
1856  SSINPS = ANSWER
1857  CONTINUE
1950  PRINT 1951
1952  CALL READIN(FLOTE)
      GO TO (1953,1000,1955,1950,1956),  IGOTO
```

```
1953  PRINT 1954
      GO TO 1957
1955  TBODAR = .85
      GO TO 1957
1956  TBODAR = ANSWER
1957  CONTINUE
2000  CONTINUE
C        READ IN SLUDGE CHARACTERISTICS
2050  PRINT 2051
2052  CALL READIN(FLOTE)
      GO TO (2053,2000,2055,2050,2056),  IGOTO
2053  PRINT 2054
      GO TO 2052
2055  ASD = .01
      GO TO 2057
2056  ASD = ANSWER
2057  CONTINUE
2150  PRINT 2151
2152  CALL READIN(FLOTE)
      GO TO (2153,2000,2155,2150,2156),  IGOTO
2153  PRINT 2154
      GO TO 2152
2155  FLOTUD = .05
      GO TO 2157
2156  FLOTUD = ANSWER
2157  CONTINUE
2250  PRINT 2251
2252  CALL READIN(FLOTE)
      GO TO (2253,2000,2255,2250,2256),  IGOTO
2253  PRINT 2254
      GO TO 2252
2255  GRAVUD = .08
      GO TO 2257
2256  GRAVUD = ANSWER
2257  CONTINUE
2350  PRINT 2351
2352  CALL READIN(FLOTE)
      GO TO (2353,2000,2355,2350,2356),  IGOTO
2353  PRINT 2354
      GO TO 2352
2355  PSETUD = .05
      GO TO 2357
2356  PSETUD = ANSWER
2357  CONTINUE
2450  PRINT 2451
2452  CALL READIN(FLOTE)
      GO TO (2453,2000,2455,2450,2456),  IGOTO
2453  PRINT 2454
      GO TO 2452
2455  VFPSLG = .78
      GO TO 2457
2456  VFPSLG = ANSWER
2457  CONTINUE
2550  PRINT 2551
2552  CALL READIN(FLOTE)
```

```
      GO TO (2553,2000,2555,2550,2556),  IGOTO
 2553 PRINT 2554
      GO TO 2552
 2555 VSANRM = .5
      GO TO 2557
 2556 VSANRM = ANSWER
 2557 CONTINUE
 2650 PRINT 2651
 2652 CALL READIN (FLOTE)
      GO TO (2653,2000,2655,2650,2656), IGOTO
 2653 PRINT 2654
      GO TO 2652
 2655 VSARM = .5
      GO TO 2657
 2656 VSARM = ANSWER
 2657 CONTINUE
 2750 PRINT 2751
 2752 CALL READIN(FLOTE)
      GO TO (2753,2000,2755,2750,2756), IGOTO
 2753 PRINT 2754
      GO TO 2752
 2755 HPDFT = 8.
      GO TO 2757
 2756 HPDFT = ANSWER
 2757 CONTINUE
 2850 PRINT 2851
 2852 CALL READIN(FLOTE)
      GO TO (2853,2000,2855,2850,2856), IGOTO
 2853 PRINT 2854
      GO TO 2852
 2855 HPDVF = 8.
      GO TO 2857
 2856 HPDVF = ANSWER
 2857 CONTINUE
 2950 PRINT 2951
 2952 CALL READIN(FLOTE)
      GO TO (2953,2000,2955,2950,2956),  IGOTO
 2953 PRINT 2954
      GO TO 2952
 2955 PSRMVE = .5
      GO TO 2957
 2956 PSRMVE = ANSWER
 2957 CONTINUE
C
C         END OF SUBROUTINE SEWAGE
      RETURN
      END
      SUBROUTINE SIZE
C
C        PURPOSE:
C           SIZE COMPUTES FOR THE CURRENT TIME PERIOD (TP), THE
C           INDEPENDENT SIZING PARAMETERS FOR EACH PROCESS WITH/WITHOUT
C           PHOSPHORUS REMOVAL TREATMENT.
C
C        COMMON BLOCKS:
C           IELIMT - INFLUENT AND EFFLUENT LIMITS
C           LIQUID - LIQUID INFLUENT INFORMATION
C           PRGCNT - PROGRAM CONTROL VARIABLES
C           SCHEME - INFO ABOUT LIQUID TREATMENT SCHEMES
C           SLCHAR - SLUDGE,LIQUID,CHEMICAL CHARACTERISTICS
C           SLGSCM -REQUIRED SLUDGE HANDLING EQUIPMENT
C           SLUDGE - SLUDGE INFORMATION
C           SEWPOP - THE SEWERED POPULATION
C           SSINK  - SOLID SINK INFORMATION
C           TIME   - PARAMETERS OF TIME HORIZON
C           TPLANT - CHARACTERISTICS OF TREATMENT PLANT PROCESSES
C
C        SUBROUTINES CALLED:
C           TSCHME(ES) - INITIALIZES IN ORDER TO SIZE WPARM
C
C        CALLED BY:
C           TRTMNT - THE MAIN COSTING SUBROUTINE
C
C        AUTHOR:
C           DAVID A BARNES   12OCT72
C
C        ------------------------------------------------------------
       COMMON /IELIMT/ IELIMT(2,20)
      1 , INF, EFF

       REAL IELIMT
       INTEGER EFF

       COMMON /LIQUID/ ALKIPS, BODIPS, MLSSAR, NH3IAR, PINPS, QAVE
      1                , QPEAK, SSINPS, TBODAR

       REAL MLSSAR, NH3IAR

       COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
      1 , YES, NO, ON, OFF
      2 , ISCHM
      3 , IDUMMY, DUMMY

       EQUIVALENCE (IANSWR,ANSWER)

       INTEGER FIXED, FLOTE, ALPHA
       INTEGER YES, ON, OFF

       COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
      1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
      2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
      3 , ALTFMF, FCTFMF, ALFBAS, FCFBAS, L1FBAS, L2FBAS, NONE
```

```
     4 , EQUIP(45)

      INTEGER ELGPTY, EQUIP, SCHEME
      INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
     1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTFMF, FCTFMF, ALFBAS
     2 , FCFBAS
      REAL MINEFP

      COMMON /SEWPOP/ FNCTYP, SPOPIN(2,5), SEWPOP(20)
     1 , YEAR, SPOP, MAXPV

      INTEGER YEAR, SPOP, FNCTYP

      COMMON /SSINK/ TRNCST, SWASTE(20), SOLSNK(2,15), SSCOST(20)
     1              , BESTSS(20), CAP, DIST, MAXSS
      INTEGER BESTSS, CAP, DIST

      COMMON /SLCHAR/    ADDSSF, ALKIAP, FCVFD , LBNVPS, LBNVSS
     1 , LBNVTS, LBVPS , LBVSS , LBVTS , LIMEPD, LMVFD , PALUM
     2 , PCO2  , PFECL , PNAAL , PNAOH , PCLYD , PPCKL , QPSLGE
     3 , QSSLGE, CTOTAL, QTSLGE, SRCAT , SRLIME, TLBNVS, TLBPS
     4 , TLBSLG, TLBSS , TLBTS , TLBVS , WCLBSS, WOPALM, WOPCO2
     5 , WOPFC , WOPLIM, WOPNAL, WOPNOH, WOPPLY, WOPPCK, WRCAT
     6 , PLIME , PYFTD , PYVFD , PPOLY , SRALF , SRCATA, WRALF
     7 , SRFEF , WRFEF , SRFEP , SRALP , WRALP , WRFEP , WRALA
     8 , WRFEA , AARATO, FFRATO, SRCATS, WRCATS, WRALS , WRFES
     9 , CO20  , SRTLIM, TSETUD, LIMETD, BCDIAR, WOTLBS

      REAL       LBNVPS, LBNVSS, LBNVTS, LBVPS , LBVSS , LBVTS
     1 , LIMEPD, LMVFD , LIMETD

      COMMON /SLGSCM/ SLGSCM(20)
      INTEGER SLGSCM

      COMMON /SLUDGE/ ASD   , FLOTUD, GRAVUD, HPDFT , HPDVF , PSETUD
     1                , PSRMVE, VFPSLG, VSANPM, VSARM

      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP

      COMMON /TPLANT/ TPLANT(16,45)
     1 , RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHAER, FLCCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGDON, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
     6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     8 , WVAR  , RPARM , BASF  , RPVAR , PARMX , MINRV , MAXRV
     9 , MAXP

      INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
     1 , DIFAIR, FLCCCP, SECSET, RE1PMP, CLFEED, CLBASN, RE2PMP
     2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
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     3 , CENFUC, FBINC , WSPOND, SLGDCN, RECRB1, RECRB2, TERST1
     4 , TERST2, ALUMFS, FECLFS, POLYFS, CO2FS , PCKLFS, RECALC
     5 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     6 , WVAR  , BPARM , FLOCCT, BASE  , APVAR , PARMX

      REAL LOCC, MLVSS

C        ****************************************************************
C        *****************                                ****************
C        *****************    START EXECUTION             ****************
C        *****************                                ****************
C        ****************************************************************
C
 1000  CONTINUE
C
C        INITIALIZE DOMAIN VARIABLES FOR THE SIZING PARAMETER FUNCTIONS
C        WITHOUT PHOSPHORUS REMOVAL
C
      CALL TSCHME(NONE)
 2000  CONTINUE
C
C        COMPUTE INDEPENDENT SIZING PARAMETER FOR EACH PROCESS
C
C        **********************
C        LIQUID PROCESSES
C        **********************
      POPR = SEWPOP(TP)/SEWPOP(1)
      TPLANT(WOPARM,RWPUMP) = QPEAK*POPR*EQUIP(RWPUMP)
      TPLANT(WOPARM,PRETRT) = QPEAK*POPR*EQUIP(PRETRT)
      IF (EQUIP(PRMSET) .EQ. OFF)  GO TO 2050
      LBVPS = QAVE*POPR*SSINPS*PSRMVE*VFPSLG*8.33
      LBNVPS = QAVE*POPR*SSINPS*PSRMVE*(1.-VFPSLG)*8.33
      TLBPS = LBVPS + LBNVPS
      TLBNVS = TLBNVS + LBNVPS
      TLBVS = TLBVS + LBVPS
      TLBSLG = TLBSLG + TLBPS
      QPSLGE = TLBPS/(PSETUD*(10.**6.)*8.33)
      QTOTAL = QTOTAL + QPSLGE
      TPLANT(WOPARM,PRMSET) = (QAVE*POPR*1000.*EQUIP(PRMSET))
     1                        /TPLANT(PVAR,PRMSET)
      TPLANT(WOPARM,PSPUMP) = (QPSLGE*(10.**6.)*EQUIP(PSPUMP))
     1                        /(TPLANT(PVAR,PSPUMP)*60.)
 2050  CONTINUE
      IF (EQUIP(TRKFTR) .EQ. OFF)  GO TO 2070
      RTURN = 1.5
      QSSLGE = .029*QAVE*POPR
C          .7 = 70 PER CENT REMOVAL OF SUSPENDED SOLIDS IN FILTER
      SSRTF = .7*(1.-PSRMVE)*SSINPS
      LBVSS = SSRTF*VFPSLG*QAVE*POPR*8.33
      L[illegible]VSS = SSRTF*(1.-VFPSLG)*QAVE*POPR*8.33
      TLBSS = LBVSS + LBNVSS
      QTOTAL = QTOTAL + QSSLGE
      TLBNVS = TLBNVS + LBNVSS
      TLBVS = TLBVS + LBVSS
      TLBSLG = TLBSLG + TLBSS
      TPLANT(WOPARM,TRKFTR) = QAVE*POPR*43560.*6.*EQUIP(TRKFTR)
     1                        /(TPLANT(PVAR,TRKFTR)*1000.)
 2070 CONTINUE
      IF (EQUIP(AERBSN) .EQ. OFF)  GO TO 2090
      FOOD = TBOCAR*BODIAR
      MLVSS = .7*MLSSAR
      VAER = (TPLANT(PVAR,AERBSN)/24.)*QAVE*POPR
      TPLANT(WOPARM,AERBSN) = (VAER/7.48)*1000.*EQUIP(AERBSN)
      URSS = (ASC*10000.)/MLSSAR
      RTURN = (1.-1.08*FOOD/MLVSS + 1.25*VAER/(QAVE*POPR))/(URSS-1.)
      IF (RTURN .LT. 1.)  RTURN = 1.
      LBOD = (.58*FOOD*QAVE*POPR+1.16*.125*MLVSS*.6*VAER+NH3IAR*4.6
     1       *QAVE*POPR)*8.33
      LBVSS = (1.08*FOOD*QAVE*POPR-.125*VAER*MLVSS)*8.33
      LBNVSS = LBVSS*(.3/.7)
      TLBNVS = TLBNVS + LBNVSS
      TLBVS = TLBVS + LBVSS
      TLBSS = LBNVSS + LBVSS
      WOLBSS = TLBSS
      QSSLGE = TLBSS/((10.**6.)*ASD*8.33)
      QTOTAL = QTOTAL + QSSLGE
      TLBSLG = TLBSLG + TLBSS
      TPLANT(WOPARM,DIFAIR) = (LBOD*EQUIP(DIFAIR))/(.075*.232
     1                        *TPLANT(PVAR,DIFAIR)*1440.*1000.)
      TENSS = (1500.*QAVE*POPR*BODIAR*8.33)/(1440.*1000.)
      IF (TPLANT(WOPARM,DIFAIR) .LT. TENSS)  TPLANT(WOPARM,DIFAIR)=TENSS
      TPLANT(WOPARM,MCHAER) = (LBOD*EQUIP(MCHAER))/(TPLANT(PVAR,MCHAER)
     1                        *24.)
      TENSS = (QAVE*POPR*BODIAR*8.33)/(TPLANT(PVAR,MCHAER)*24.)
      IF (TPLANT(WOPARM,MCHAER) .LT. TENSS)  TPLANT(WOPARM,MCHAER)=TENSS
 2090 CONTINUE
      TPLANT(WOPARM,FLOCCP) = QAVE*POPR*EQUIP(FLOCCP)
      TPLANT(WOPARM,FLOCCT) = 0.
      TPLANT(WOPARM,SECSET) = (QAVE*POPR*1000.*EQUIP(SECSET))
     1                        /TPLANT(PVAR,SECSET)
      TPLANT(WOPARM,RE1PMP) = QAVE*POPR*RTURN*EQUIP(RE1PMP)
      TPLANT(WOPARM,CLFEED) = QPEAK*POPR*TPLANT(PVAR,CLFEED)*8.33
     1                        *EQUIP(CLFEED)
      TPLANT(WOPARM,CLBASN) = (QPEAK*POPR*TPLANT(PVAR,CLBASN)
     1                        *EQUIP(CLBASN))/(1.440*7.48)
      TPLANT(WOPARM,MULFTR) = QAVE*POPR*EQUIP(MULFTR)
      TPLANT(WOPARM,RE2PMP) = QPEAK*POPR*EQUIP(RE2PMP)
      TPLANT(WOPARM,RECRB1) = 0.
      TPLANT(WOPARM,RECRB2) = 0.
      TPLANT(WOPARM,TERST1) = 0.
      TPLANT(WOPARM,TERST2) = 0.
C        *********************
C        SLUDGE PROCESSES
C        *********************
C        IF THERE IS AN AIR FLOTATION THICKENER ,THEN IT HANDLES
C        BIOLOGICAL AND SECONDARY SLUDGE ONLY
      IF (EQUIP(FLOTKN) .EQ. OFF)  GO TO 2110
      TPLANT(WOPARM,FLOTKN) = TLBSS*EQUIP(FLOTKN)/(TPLANT(PVAR,FLOTKN)
     1                        *HPDFT)
      PPOLY = PPOLY + PYFTD*TLBSS/2000.
      TPLANT(WOPARM,GRVTKN) = TLBPS/(TPLANT(PVAR,GRVTKN)*1000.)
      QTOTAL = (TLBSS/FLOTUD + TLBPS/GRAVUD)/(8.33*(10.**6.))
     1          /(8.33*(10.**6.))
      GO TO 2130
 2110 CONTINUE
      QTOTAL = TLBSLG/(GRAVUD*8.33*(10.**6.))
      TPLANT(WOPARM,GRVTKN) = TLBSLG/(TPLANT(PVAR,GRVTKN)*1000.)
 2130 CONTINUE
      VSREM = 1.
      IF (EQUIP(AERDIG) .EQ. OFF)  GO TO 2150
      TPLANT(WOPARM,AERDIG) = (TPLANT(PVAR,AERDIG)*EQUIP(AERDIG)
                              *QTOTAL*1000.)/7.48
     1
      VSREM = VSARM
 2150 CONTINUE
      IF (EQUIP(ANADIG) .EQ. OFF)  GO TO 2170
      TPLANT(WOPARM,ANADIG) = (TPLANT(PVAR,ANADIG)*EQUIP(ANADIG)
                              *QTOTAL*1000.)/7.48
     1
      TENSS = TLBVS / 40.
      IF (TPLANT(WOPARM,ANADIG) .LT. TENSS)  TPLANT(WOPARM,ANADIG)=TENSS
      VSREM = VSANRM
C
C        DO NOT BUILD ANY ADDITIONAL ANAEROBIC DIGESTERS
C        BUT USE PRESENT DIGESTERS TO FULL CAPACITY
      IF (TPLANT(WOPARM,ANADIG) .LE. TPLANT(PPARM,ANADIG))  GO TO 2160
C        X IS THE AMOUNT WHICH PASSES THRU THE DIGESTER
      X = TPLANT(PPARM,ANADIG) / TPLANT(WOPARM,ANADIG)
      TPLANT(WOPARM,ANADIG) = TPLANT(PPARM,ANADIG)
      TLBVS = TLBVS * ((1-X) + X*VSREM)
      GO TO 2170
 2160 TLBVS = TLBVS*VSREM
 2170 CONTINUE
      TPLANT(WOPARM,DRYBED) = TPLANT(PVAR,DRYBED)*SEWPCP(TP)
                              *EQUIP(DRYBED)/1000.
     1
      TPLANT(WOPARM,SLDTNK) = (QTOTAL*TPLANT(PVAR,SLDTNK)*EQUIP(SLDTNK)
                              *1000.)/7.48
     1
      IF (EQUIP(VACFTR) .EQ. OFF)  GO TO 2190
      TPLANT(WOPARM,VACFTR) = (TLBNVS + TLBVS)*EQUIP(VACFTR)
                              /(TPLANT(PVAR,VACFTR)*HPDVF)
     1
      CCN = (TLBNVS+TLBVS)/2000.
      PFECL = PFECL + FCVFD*CCN
      PLIME = PLIME + LMVFD*CON
 2190 CONTINUE
      TPLANT(WOPARM,CENFUG) = QTOTAL*(10.**6.)*EQUIP(CENFUG)
                              /(1440.*TPLANT(PVAR,CENFUG))
     1
      TPLANT(WOPARM,MHINC) = (TLBNVS + TLBVS)*EQUIP(MHINC)
                              /TPLANT(PVAR,MHINC)
     1
      TPLANT(WOPARM,FBINC ) = (TLBNVS + TLBVS)*EQUIP(FBINC )
                              /TPLANT(PVAR,FBINC )
     1
      IF (EQUIP(MHINC) .EQ. ON .OR. EQUIP(FBINC) .EQ. ON)
     1   TLBVS = 0.
      TPLANT(WOPARM,WSPOND) = 0.
      TPLANT(WOPARM,SLGCON) = 0.
      TPLANT(WOPARM,SECALC) = .001
      WOTLBS = TLBNVS + TLBVS
C        *********************
```

```
C          CHEMICAL HANDLING PROCESSES
C          **********************
      WOPALM = PALUM
      WOPCO2 = PCO2
      WOPFC  = PFECL
      WOPLIM = PLIME
      WOPNAL = PNAAL
      WOPNOH = PNAOH
      WOPPCK = PPCKL
      WOPPLY = PPOLY
      TPLANT(WOPARM,ALUMFS) = PALUM/11.*EQUIP(ALUMFS)
      TPLANT(WOPARM,FECLFS) = PFECL/2.89*EQUIP(FECLFS)
      TPLANT(WOPARM,LIMEFS) = PLIME*EQUIP(LIMEFS)
      TPLANT(WOPARM,POLYFS) = PPOLY*EQUIP(POLYFS)
      TPLANT(WOPARM,CO2 FS) = PCO2 *EQUIP(CO2 FS)
      TPLANT(WOPARM,NAALFS) = PNAAL/4.22*EQUIP(NAALFS)
      TPLANT(WOPARM,PCKLFS) = PPCKL/2.27*EQUIP(PCKLFS)
      TPLANT(WOPARM,NAOHFS) = PNAOH*EQUIP(NAOHFS)
C
C          INITIALIZE DOMAIN VARIABLES FOR THE SIZING PARAMETER FUNCTIONS
C          WITH PHOSPHORUS REMOVAL
C
      CALL TSCHME(ISCHM)
4000  CONTINUE
C
C          COMPUTE INDEPENDENT SIZING PARAMETER FOR EACH PROCESS
C
C          *********************
C          LIQUID PROCESSES
C          *********************
      TPLANT(WPARM, RWPUMP) = QPEAK*POPR*EQUIP(RWPUMP)
      TPLANT(WPARM, PRETRT) = QPEAK*POPR*EQUIP(PRETRT)
      IF (EQUIP(PPMSET) .EQ. OFF)  GO TO 4050
      ADDSSR = AMIN1(ADDSSR,(SSINPS*1.-PSRMVE))
      LBVPS = (SSINPS*PSRMVE+ADDSSR)*QAVE*POPR*VFPSLG*8.33
      LBNVPS = (WRCAT*SRCAT*IELIMT(INF,TP)+(SSINPS*PSRMVE+ADDSSR)
     1         *(1.-VFPSLG)+SRLIME/8.33)*QAVE*POPR*8.33
      TLBPS = LBVPS + LBNVPS
      TLBNVS = TLBNVS + LBNVPS
      TLBVS = TLBVS + LBVPS
      TLBSLG = TLBSLG + TLBPS
      QPSLGE = TLBPS/(PSETUD*(10.**6.)*8.33)
      QTOTAL = QTOTAL + QPSLGE
      CON = QAVE*POPR*8.33
      PALUM = PALUM + WRALP*IELIMT(INF,TP)*AARATO*CON
      PFECL = PFECL + WRFEP*IELIMT(INF,TP)*FERATO*CON
      PLIME = PLIME + LIMEPD*CON
      PPOLY = PPOLY + POLYD*CON
      TPLANT(WPARM, PRMSET) = (QAVE*POPR*1000.*EQUIP(PRMSET))
     1                        /TPLANT(WVAR,PRMSET)
      TPLANT(WPARM, PSPUMP) = (QPSLGE*(10.**6.)*EQUIP(PSPUMP))
     1                        /(TPLANT(WVAR,PSPUMP)*60.)
4050  CONTINUE
      IF (EQUIP(TPKFTR) .EQ. OFF)  GO TO 4070
      RTURN = 1.5
      QSSLGE = .029*QAVE*PCPR
C        .7 = 70 PEP CENT REMOVAL OF SUSPENDED SOLIDS IN FILTEF
      SSRTF = .7*(1.-PSRMVE)*SSINPS
      LBVSS = SSRTF*VFPSLG*QAVE*POPR*8.33
      LBNVSS = (SSRTF*(1.-VFPSLG)+WRALF*SRALF*IELIMT(INF,TP)
     1          +SRFEF*WRFEF*IELIMT(INF,TP))*QAVE*POPR*8.33
      TLBSS = LBVSS + LBNVSS
      QTOTAL = QTCTAL + QSSLGE
      TLBNVS = TLBNVS + LBNVSS
      TLBVS = TLBVS + LBVSS
      TLBSLG = TLPSLG + TLBSS
      PALUM = PALUM + WRALF*IELIMT(INF,TP)*AARATO*CON
      PFECL = PFECL + WRFEF*IELIMT(INF,TP)*FFRATO*CON
      TPLANT(WPARM, TRKFTR) = QAVE*POPR*43560.*6.*EQUIP(TRKFTR)
                              /(TPLANT(WVAR,TRKFTR)*1000.)
     1
 4070 CONTINUE
      IF (EQUIP(AERBSN) .EQ. OFF) GO TO 4090
      FOOD = TBODAR * BCDIAR
      MLVSS = .7*MLSSAR
      VAER = (TPLANT(WVAR,AERBSN)/24.)*QAVE*POPR
      TPLANT(WPARM, AERBSN) = (VAER/7.48)*1000.*EQUIP(AERBSN)
      URSS = (ASD*10000.)/MLSSAR
      RTURN = (1.-1.08*FOOD/MLVSS + 1.25*VAER/(QAVE*POPR))/(URSS-1.)
      IF (RTURN .LT. 1.)  RTURN = 1.
      LBOD = (.58*FCOD*QAVE*POPR+1.16*.125*MLVSS*.6*VAER+NH3IAR*4.6
     1         *QAVE*POPR)*8.33
      LBVSS = (1.C8*FOOD*QAVE*POPR-.125*VAER*MLVSS)*8.33
      SCON = SRCATA*IELIMT(INF,TP)*QAVE*POPR*8.33
      LBNVSS = LBVSS*.3/.7 + (WRFEA + WRALA)*SCON
      TLBNVS = TLBNVS + LBNVSS
      TLBVS = TLBVS + LBVSS
      TLBSS = LBNVSS + LBVSS
      QSSLGE = TLBSS/((10.**6.)*ASD*8.33)
      QTOTAL = QTCTAL + QSSLGE
      TLBSLG = TLBSLG + TLBSS
      PALUM = PALUM + WRALA*IELIMT(INF,TP)*AARATO*CON
      PFECL = PFECL + WRFEA*IELIMT(INF,TP)*FFRATO*CON
      PNAAL = PNAAL + WRALA*IELIMT(INF,TP)*AARATO*CON
      TPLANT(WPARM, DIFAIR) = (LBOD*EQUIP(DIFAIR))/(.075*.232
                              *TPLANT(WVAR,DIFAIR)*1440.*1000.)
     1
      TENSS = (1500.*QAVE*POPR*BCDIAR*8.33)/(1440.*1000.)
      IF (TPLANT(WPARM, DIFAIR) .LT. TENSS)  TPLANT(WPARM, DIFAIR)=TENSS
      TPLANT(WPARM, MCHAER) = (LBOD*EQUIP(MCHAER))/(TPLANT(WVAR,MCHAER)
     1                        *24.)
      TENSS = (QAVE*POPR*BODIAR*8.33)/(TPLANT(WVAR,MCHAER)*24.)
      IF (TPLANT(WPARM, MCHAER) .LT. TENSS)  TPLANT(WPARM, MCHAER)=TENSS
 4090 CONTINUE
      TPLANT(WPARM, FLOCCP) = QAVE*POPR*EQUIP(FLOCCP)
      TPLANT(WPARM, FLOCCT) = QAVE*POPR*EQUIP(FLOCCT)
      TPLANT(WPARM, SECSET) = (QAVE*POPR*1000.*EQUIP(SECSET))
     1                        /TPLANT(WVAR,SECSET)
      TPLANT(WPARM, RE1PMP) = QAVE*POPR*RTURN*EQUIP(RE1PMP)
      TPLANT(WPARM, CLFEED) = QPEAK*POPR*TPLANT(WVAR,CLFEED)*8.33
     1                        *EQUIP(CLFEED)
      TPLANT(WPARM, CLBASN) = (QPEAK*POPR*TPLANT(WVAR,CLBASN)
     1                          *EQUIP(CL3ASN))/(1.440*7.48)
      TPLANT(WPARM, MULFTR) = QAVE*POPR*EQUIP(MULFTR)
      TPLANT(WPARM, RE2PMP) = QPEAK*POPR*EQUIP(RE2PMP)
      TPLANT(WPARM, RECRB1) = QAVE*POPR*1000.*TPLANT(WVAR,RECRB1)
     1                        /(1440.*7.48)
      TPLANT(WPARM, RECRB2) = QAVE*POPR*1000.*TPLANT(WVAR,RECRB2)
     1                         /(1440.*7.48)
      PCO2 = CO2C*QAVE*POPR
      IF (EQUIP(TERST1) .EQ. OFF) GO TO 4095
      TPLANT(WPARM, TERST1) = (QAVE*POPR*1000.*EQUIP(TERST1))
     1                         /TPLANT(WVAR,TERST1)
      LBVTS = 0.
      LBNVTS = (IELIMT(INF,TP)*WRCATS*SRCATS+SRTLIM/8.33)
     1         *(QAVE*POPR*8.33)
C        TERTIARY LIME SLUDGE IS RECALINATED SEPARATELY
C        FROM OTHER SLUDGE
      IF (EQUIP(RECALC) .EQ. ON .AND. LIMETD .GT. 0.)  GO TO 4093
      TLBNVS = TLBNVS + LBNVTS
      TLBVS = TLBVS + LBVTS
      TLBTS = LBNVTS + LBVTS
      TLBSLG = TLBSLG + TLBTS
      QTSLGE = TLBTS/(TSETUD*(10.**6.)*8.33)
      QTOTAL = QTOTAL + QTSLGE
4093  CONTINUE
      CON = QAVE*POPR*8.33
      PALUM = PALUM + IELIMT(INF,TP)*WRALS*AARATO*CON
      PFECL = PFECL + IELIMT(INF,TP)*WRFES*FFRATO*CON
      PLIME = PLIME + LIMETD*CON
4095  CONTINUE
      IF (EQUIP(TERST2) .EQ. OFF)  GO TO 4097
      TPLANT(WPARM, TERST2) = (QAVE*POPR*1000.*EQUIP(TERST2))
     1                         /TPLANT(WVAR,TERST2)
      LBVTS = 0.
      LBNVTS = 0.
      TLBNVS = TLBNVS + LBNVTS
      TLBVS = TLBVS + LBVTS
      TLBTS = LBNVTS + LBVTS
      TLBSLG = TLBSLG + TLBTS
      QTSLGE = QTSLGE + TLBTS/(TSETUD*(10.**6.)*8.33)
      QTOTAL = QTOTAL + QTSLGE
4097  CONTINUE
C        **********************
C        SLUDGE PROCESSES
C        **********************
C        IF THERE IS AN AIR FLOTATION THICKENER ,THEN IT HANDLES
C        BIOLOGICAL AND SECONDARY SLUDGE ONLY
      IF (EQUIP(FLOTKN) .EQ. OFF)  GO TO 4110
      TPLANT(WPARM, FLOTKN) = TLBSS*EQUIP(FLOTKN)
     1                         /(TPLANT(WVAR,FLOTKN)*HPDFT)
      PPOLY = PPOLY + PYFTD*TLBSS/2000.
      TPLANT(WPARM, GRVTKN) = (TLBPS+TLBTS)/(TPLANT(WVAR,GRVTKN)*1000.)
      QTOTAL = (TLBSS/FLOTUD + (TLBPS+TLBTS)/GRAVUD)
     1         /(8.33*(10.**6.))
      GO TO 4130
4110  CONTINUE
```

```
      QTOTAL = TLBSLG/(GRAVUD*8.33*(10.**6.))
      TPLANT(WPARM, GRVTKN) = TLBSLG/(TPLANT(WVAR,GRVTKN)*1000.)
 4130 CONTINUE
      VSREM = 1.
      IF (EQUIP(AERDIG) .EQ. OFF)  GO TO 4150
      TPLANT(WPARM, AERDIG) = (TPLANT(WVAR,AERDIG)*EQUIP(AERDIG)
     1                        *QTOTAL*1000.)/7.48
      VSREM = VSARM
 4150 CONTINUE
      IF (EQUIP(ANADIG) .EQ. OFF)  GO TO 4170
      TPLANT(WPARM, ANADIG) = (TPLANT(WVAR,ANADIG)*EQUIP(ANADIG)
     1                        *QTOTAL*1000.)/7.48
      TENSS = TLBVS / 40.
      IF (TPLANT(WPARM, ANADIG) .LT. TENSS)  TPLANT(WPARM, ANADIG)=TENSS
      VSREM = VSANRM
C
C        DO NOT BUILD ANY ADDITIONAL ANAEROBIC DIGESTERS
C        BUT USE PRESENT DIGESTERS TO FULL CAPACITY
      IF (TPLANT(WPARM,ANADIG) .LE. TPLANT(PPARM,ANADIG))  GO TO 4160
C        X IS THE AMOUNT WHICH PASSES THRU THE DIGESTER
      X = TPLANT(PPARM,ANADIG) / TPLANT(WPARM,ANADIG)
      TPLANT(WPARM,ANADIG) = TPLANT(PPARM,ANADIG)
      TLBVS = TLBVS * ((1-X) + X*VSREM)
      GO TO 4170
 4160 TLBVS = TLBVS*VSREM
 4170 CONTINUE
      TPLANT(WPARM, DRYBED) = TPLANT(WVAR,DRYBED)*SEWPCP(TP)
     1                        *EQUIP(DRYBED)/1000.
      TPLANT(WPARM, SLDTNK) = (QTOTAL*TPLANT(WVAR,SLDTNK)*EQUIP(SLDTNK)
     1                        *1000.)/7.48
      IF (EQUIP(VACFTR) .EQ. OFF)  GO TO 4190
      TPLANT(WPARM, VACFTR) = (TLBNVS + TLBVS)*EQUIP(VACFTR)
     1                        /(TPLANT(WVAR,VACFTR)*HPDVF)
      CON = (TLBNVS+TLBVS)/2000.
      PFECL = PFECL + FCVFD*CON
      PLIME = PLIME + LMVFD*CON
 4190 CONTINUE
      TPLANT(WPARM, CENFUG) = QTOTAL*(10.**6.)*EQUIP(CENFUG)
     1                        /(1440.*TPLANT(WVAR,CENFUG))
      TPLANT(WPARM, MHINC) = (TLBNVS + TLBVS)*EQUIP(MHINC)
     1                        /TPLANT(WVAR,MHINC)
      TPLANT(WPARM, FBINC ) = (TLBNVS + TLBVS)*EQUIP(FBINC )
     1                        /TPLANT(WVAR,FBINC )
C        VOLATILE SLUDGE IS REDUCED TO 0. IF THERE IS INCINERATION
      IF (EQUIP(MHINC) .EQ. ON .OR. EQUIP(FBINC) .EQ. ON)
     1  TLBVS = 0.
      TPLANT(WPARM, WSPOND) = 0.
      TPLANT(WPARM, SLGOON) = QAVE*POPR*TPLANT(WVAR,SLGOON)*1000./7.48
C        WITH RECALINATION ONLY 35 PERCENT OF TOTAL LIME IS FRESH
      TPLANT(WPARM,RECALC) = QAVE*POPR*EQUIP(RECALC)
      IF (EQUIP(RECALC) .EQ. ON)  PLIME = .35 * PLIME
C
C        IF DESIGNING A WHOLE NEW PLANT THEN SWASTE IS ALL
      SWCON = TLBNVS+TLBVS
      IF (TPLANT(PPARM,RWPUMP) .GT. 0.)  SWCON=TLBNVS+TLBVS-WOTLBS
      SWASTE(TP) = SWCON/2000.*365.*TPSIZE
C        **********************
C        CHEMICAL HANDLING PROCESSES
C        **********************
      TPLANT(WPARM, ALUMFS) = PALUM/11.*EQUIP(ALUMFS)
      TPLANT(WPARM, FECLFS) = PFECL/2.89*EQUIP(FECLFS)
      TPLANT(WPARM, LIMEFS) = PLIME*EQUIP(LIMEFS)
      TPLANT(WPARM, POLYFS) = PPOLY*EQUIP(POLYFS)
      TPLANT(WPARM, CO2 FS) = PCO2 /1440./.123/1000.*EQUIP(CO2 FS)
      TPLANT(WPARM, NAALFS) = PNAAL/4.22*EQUIP(NAALFS)
      TPLANT(WPARM, PCKLFS) = PPCKL/2.27*EQUIP(PCKLFS)
      TPLANT(WPARM, NAOHFS) = PNAOH*EQUIP(NAOHFS)
C
C
C        END OF SUBROUTINE SIZE
      RETURN
      END
      SUBROUTINE SPFNC
C
C        PURPOSE:
C             SPFNC COMPUTES THE SIZE OF THE SEWERED POPULATION OVER ALL
C           TIME PERIODS OF A GIVEN CONTROL STRATEGY.
C
C        COMMON BLOCKS:
C           SEWPOP  - THE SEWERED POPULATION
C           TIME    - PARAMETERS OF TIME HORIZON
C
C        CALLED BY:
C           INTIME  - READS IN TIME HORIZON OF CONTROL STRATEGY
C
C        AUTHOR:
C           DAVID A BARNES   06OCT72
C
C        ---------------------------------------------------------------
      COMMON /SEWPOP/ FNCTYP, SPOPIN(2,5), SEWPOP(20)
     1 , YEAR, SPOP, MAXPV

      INTEGER YEAR, SPOP, FNCTYP

      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP


C        ***************************************************************
C        ****************                                ***************
C        ****************    START EXECUTION             ***************
C        ****************                                ***************
C        ***************************************************************
C
C
C        GO TO APPROPRIATE TYPE OF FUNCTION
      GO TO (1000,2000,3000,4000), FNCTYP
C
C        ASSUMED LINEAR WITH 5 PERCENT GROWTH RATE
 1000 CONTINUE
      SLOPE = .05 * SPOPIN(SPOP,1)
      GO TO 2500
 2000 CONTINUE
      POPDLT = SPOPIN(SPOP,2) - SPOPIN(SPOP,1)
      TDELT =(SPOPIN(YEAR,2) - SPOPIN(YEAR,1))/TPSIZE
      SLOPE = POPDLT/TDELT
 2500 CONTINUE
C
C        LINEAR GROWTH FUNCTION WITH COMPUTED GROWTH RATE
C
C        FILL IN SEWERED POPULATION ARRAY
      DO 2900 TP = 1,MAXTP
      SEWPOP(TP)  = SLOPE*TP + SPOPIN(SPOP,1)
 2900 CONTINUE
      RETURN
C
C        EXPONENTIAL GROWTH FUNCTION
```

```
3000  CONTINUE
      SPRATO = SPOPIN(SPOP,2) / SPOPIN(SPOP,1)
      SPCON = ALOG(SPRATO)
      TDELT = (SPOPIN(YEAR,2)-SPOPIN(YEAR,1))/TPSIZE
      EXPCON = EXP(SPCON/TDELT)
C
C        FILL IN SEWERED POPULATION ARRAY
      DO 3900 TP = 1,MAXTP
      SEWPOP(TP)  = SPOPIN(SPOP,1)*EXPCON**TP
3900  CONTINUE
      RETURN
C
C        PIECE-WISE LINEAR GROWTH FUNCTION
4000  CONTINUE
      IFPV = 1
      DO 4900 TP = 1,MAXTP
C        CHANGE THIS TP TO A YEAR
      YEARTP = SPOPIN(YEAR,1) + TP*TPSIZE
      DO 4500 IPV = IFPV,MAXPV
      IF (YEARTP .LT. SPOPIN(YEAR,IPV))  GO TO 4600
4500  CONTINUE
      GO TO 4700
4600  IFPV = IPV
      TDELT = (SPOPIN(YEAR,IPV) - SPOPIN(YEAR,IPV-1))/TPSIZE
      PINIT = SPOPIN(SPOP,IPV-1)
      POPDLT = SPOPIN(SPOP,IPV) - PINIT
      SLOPE = POPDLT/TDELT
C
C        FILL IN SEWERED POPULATION ARRAY
4700  ATP = (YEARTP-SPOPIN(YEAR,IFPV-1))/TPSIZE
      SEWPOP(TP) = SLOPE*ATP + PINIT
4900  CONTINUE
      RETURN
C
C        END OF SUBROUTINE SPFNC
      END
      SUBROUTINE SSKCST
C
C        PURPOSE:
C           SSKCST COMPUTES THE COST OF TRANSPORTING THE SOLID WASTE
C           FROM THE TREATMENT PLANT TO A SINK WITH SUFFICIENT CAPACITY.
C           THIS IS DONE FOR EACH TIME PERIOD.
C
C        COMMON BLOCKS:
C           PRGCNT - PROGRAM CONTROL VARIABLES
C           SSINK  - CHARACTERISTICS OF THE SOLID SINKS
C
C        CALLED BY:
C           REMOVE - THE MAIN PROGRAM
C
C        AUTHOR:
C           DAVID A BARNES    12OCT72
C
C        ----------------------------------------------------------------
      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /SSINK/ TRNCST, SWASTE(20), SCLSNK(2,15), SSCOST(20)
     1              , BESTSS(20), CAP, DIST, MAXSS
      INTEGER BESTSS, CAP, DIST

      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP

      COMMON /TSCST/ CNSTRC, MATRLS

      REAL MATRLS


      DIMENSION DSINK(2,15)

 6010 FORMAT (1H ,'***** WARNING - ALL SOLID SINKS ARE COMPLETELY FILLED
     1 ')

C        *****************************************************************
C        ****************                                ****************
C        ****************    START EXECUTION             ****************
C        ****************                                ****************
C        *****************************************************************
C
 1000 CONTINUE
C
```

```
C          SET CAPACITY OF DUMMY SINKS TO ACTUAL SINKS
      DO 1500 ISNK = 1,MAXSS
      DSINK(CAP,ISNK) = SOLSNK(CAP,ISNK)
 1500 CONTINUE
C
C          COMPUTE THE COST FOR EVERY TIME PERIOD
      DO 5000 TP = 1,MAXTP
      DSTMIN = 99999.
      BESTSS(TP) = 99
      SSCOST(TP) = 0.
C
C          SEARCH ALL SINKS TO FIND A SINK FOR EACH TIME PERIOD WHICH:
C             1. HAS SUFFICIENT CAPACITY, AND
C             2. IS THE CLOSEST.
      DO 4000 ISS = 1,MAXSS
      IF (SWASTE(TP) .GT. DSINK(CAP,ISS))  GO TO 3500
      IF (SOLSNK(DIST,ISS) .GT. DSTMIN)  GO TO 3500
      DSTMIN = SOLSNK(DIST,ISS)
      BESTSS(TP) = ISS
 3500 CONTINUE
 4000 CONTINUE
      IF (BESTSS(TP) .EQ. 99)  GO TO 5000
C          REDUCE CAPACITY OF CHOSEN SINK BY AMOUNT OF SOLID WASTE FOR
C          THIS TIME PERIOD
      DSINK(CAP,BESTSS(TP)) = DSINK(CAP,BESTSS(TP)) - SWASTE(TP)
C          COMPUTE COST OF CHOSEN SINK
      SSCOST(TP) = TRNCST * SWASTE(TP) * SOLSNK(DIST,BESTSS(TP))
 5000 CONTINUE
C
C          PRINT WARNING MESSAGE THAT ALL SINKS ARE COMPLETELY FILLED
 6000 CONTINUE
      DO 6700 TP = 1,MAXTP
      IF (BESTSS(TP) .EQ. 99)  GO TO 6800
 6700 CONTINUE
      GO TO 6900
 6800 PRINT 6010
 6900 CONTINUE
C
C          END OF SUBROUTINE SSKCST
      RETURN
      END
      SUBROUTINE STRTGY
C
C        PURPOSE:
C           STRTGY CALLS THE SUBROUTINES WHICH READ IN VALUES FOR
C           THE VARIABLES OF THE DESIRED CONTROL STRATEGY.
C           THESE VARIABLES ARE IN THE CATEGORIES OF: TIME, EFFLUENT
C           LIMITS, DETERGENT RESTRICTIONS, AND INDUSTRIAL CONTROLS.
C
C        SUBROUTINES CALLED:
C           DTGLIM  - READS IN RESTRICTIONS ON DETERGENT PHOSPHATES
C           EFFLIM  - READS IN RESTRICTIONS ON TREATMENT PLANT EFFLUENT
C           INDLIM  - READS IN RESTRICTIONS ON INDUSTRIAL EFFLUENTS
C           INTIME  - READS IN DESCRIPTION OF TIME HORIZON
C
C        CALLED BY:
C           REMOVE  - THE MAIN PROGRAM
C
C        AUTHOR:
C           DAVID A BARNES   06OCT72
C
C        ---------------------------------------------------------------
C
C        ***************************************************************
C        ****************                              ****************
C        ****************    START EXECUTION           ****************
C        ****************                              ****************
C        ***************************************************************
C
C        READ IN DESCRIPTION OF TIME HORIZON
      CALL INTIME
C
C        READ IN PHOSPHORUS EFFLUENT RESTRICTIONS
      CALL EFFLIM
C
C        READ IN RESTRICTIONS ON PHOSPHATES IN DETERGENTS
      CALL DTGLIM
C
C        READ IN RESTRICTIONS ON INDUSTRIAL PHOSPHORUS EFFLUENTS
      CALL INDLIM
C
C        END OF SUBROUTINE STRTGY
      RETURN
      END
      SUBROUTINE SYSTEM
C
C        PURPOSE:
C           SYSTEM CALLS THE SUBROUTINES WHICH READ IN A DESCRIPTION OF
C           THE TOTAL WASTE SYSTEM. THIS DESCRIPTION CONSISTS OF THE
C           CHARACTERISTICS OF THE COMMUNITY, THE INFLUENT SEWAGE, AND
C           THE TREATMENT PLANT.
C
C        SUBROUTINES CALLED:
C           CMMNTY  - READS IN DESCRIPTION OF COMMUNITY
C           SEWAGE  - READS IN DESCRIPTION OF INFLUENT SEWAGE
C           PLANT   - READS IN DESCRIPTION OF TREATMENT PLANT
C
C        CALLED BY:
C           REMOVE  - THE MAIN PROGRAM
C
C        AUTHOR:
C           DAVID A BARNES   05OCT72
C
C        ------------------------------------------------------------
C
C        ************************************************************
C        ****************                            ****************
C        ****************    START EXECUTION         ****************
C        ****************                            ****************
C        ************************************************************
C
C        READ IN DESCRIPTION OF COMMUNITY
      CALL CMMNTY
C
C        READ IN DESCRIPTION OF SEWAGE
      CALL SEWAGE
C
C        READ IN DESCRIPTION OF PLANT
      CALL PLANT
C
C        END OF SUBROUTINE
      RETURN
      END
      SUBROUTINE TRTMNT
C
C        PURPOSE:
C           TRTMENT IS THE MAIN COST COMPUTING SUBROUTINE. IT FIRST
C           DETERMINES WHAT ADDITIONAL (IF ANY) SLUDGE HANDLING
C           EQUIPMENT IS REQUIRED BY THE COMBINATION OF THIS TREATMENT
C           PLANT AND ELIGIBLE TREATMENT SCHEME.  THEN FOR EACH TIME
C           PERIOD THE FOLLOWING WILL BE COMPUTED.
C           1. SIZE AND COST OF ADDITIONAL EQUIPMENT
C           2. OPERATION AND MAINTAINENCE COSTS
C           3. MATERIAL AND SUPPLY COSTS.
C           NOTE: THE ABOVE COSTS ARE ONLY THOSE ATTRIBUTABLE TO
C                 PHOSPHORUS REMOVAL
C
C        COMMON BLOCKS:
C           PRGCNT - PROGRAM CONTROL VARIABLES
C           SCHEME - INFO ABOUT LIQUID TREATMNET SCHEMES
C           TPLANT - INFO. ABOUT LIQUID TREATMENT PROCESSES
C           TIME   - PARAMETERS OF TIME HORIZON
C
C        SUBROUTINES CALLED:
C           BUILD  - DETERMINES MAXIMUM SIZE OF ADDITIONAL EQUIPMENT
C           SCHOSE - CHOOSES SLUDGE HANDLING PROCESSES
C           SIZE   - COMPUTE INDEPENDENT SIZING PARAMETERS FOR PROCESSES
C           TRT1   - COMPUTES O & M COSTS
C           TRT2   - COMPUTES O & M COSTS
C           CONCST - COMPUTS CONSTRUCTION COSTS
C
C        CALLED BY:
C           REMOVE - THE MAIN PROGRAM
C
C        AUTHOR:
C           DAVID A BARNES   23 MAR 73
C
C        ------------------------------------------------------------
C
      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
     1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
     2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
     3 , ALTFMF, FCTFMF, ALFBAS, FCFBAS, L1FBAS, L2FBAS, NONE
     4 , EQUIP(45)

      INTEGER ELGBTY, EQUIP, SCHEME
      INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
     1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTFMF, FCTFMF, ALFBAS
```

```
      2 , FCFPAS
       REAL MINEFP

       COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

       INTEGER TP

       COMMON /TPLANT/ TPLANT(16,45)
      1 , RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
      2 , MCHAER, FLCCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
      3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
      4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGOCN, RECRB1
      5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
      6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
      7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
      8 , WVAR  , BPARM , BASE  , APVAR , PARMX , MINRV , MAXRV
      9 , MAXP

       INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
      1 , DIFAIR, FLCCCP, SECSET, RE1PMP, CLFEED, CLBASN, RE2PMP
      2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
      3 , CENFUG, FBINC , WSPOND, SLGOON, RECRB1, RECRB2, TERST1
      4 , TERST2, ALUMFS, FECLFS, POLYFS, CO2FS , PCKLFS, RECALC
      5 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
      6 , WVAR  , BPARM , FLOCCT, BASE  , APVAR , PARMX


3351   FORMAT (1H ,'SUPRESS?')
3354   FORMAT (1H ,'DO YOU WISH TO SUPRESS THE WARNING MESSAGES? (YES/NO)
      1 ')
3550   FORMAT (1H ,'***** WARNING - THE VALUE OF THE SIZING PARAMETER FOR
      1 PROCESS ''',3A4,''' = ',F10.3,/16X,' LIES OUTSIDE THE RANGE '
      2 ,F10.3,' TO ',F10.3)

C          ************************************************************
C          ****************                            ****************
C          ****************   START EXECUTION          ****************
C          ****************                            ****************
C          ************************************************************
C
1000   CONTINUE
C
C          PICK THE APPROPRIATE SLUDGE HANDLING PROCESSES
       CALL SCHCSE
C
C          COMPUTE, FOR EVERY TIME PERIOD, THE INDEPENDENT SIZING
C          PARAMETER FOR EACH PROCESS, WITH AND WITHOUT PHOSPHORUS
C          REMOVAL.  THEN COMPUTE THE ADDITIONAL SIZE NEEDED TO BE BUILT.
       DO 2000 TP = 1,MAXTP
       CALL SIZE
       CALL BUILD
2000   CONTINUE
3000   CONTINUE
       IF (IPASS .NE. 0)  GO TO 3500
       IPASS = 1
```

```
C
C        ASK USER IF HE/SHE DESIRES TO SUPRESS WARNING MESSAGES
3300  CONTINUE
3350  PRINT 3351
3352  CALL READIN(ALPHA)
      GO TO (3353,3000,3355,3350,3356), IGOTO
3353  PRINT 3354
      GO TO 3352
3355  IANSWR = NO
      GO TO 3357
3356  CONTINUE
3357  CONTINUE
      IF (IANSWR .EC. YES)  ISUP = ON
      IF (IANSWR .EQ. NO) ISUP = OFF
3500  CONTINUE
C
C        CHECK VALUE OF BPARM TO SEE IF IT LIES WITHIN CORRECT RANGE
      DO 3900 IPROC = 1,MAXP
      IF (EQUIP(IPROC) .EQ. OFF)  GO TO 3900
      IF (TPLANT(BPARM,IPROC) .EQ. 0.)  GO TO 3900
      IF ((TPLANT(BPARM,IPROC) .LT. TPLANT(MINRV,IPROC) .OR.
     1  TPLANT(BPARM,IPROC) .GT. TPLANT(MAXRV,IPROC)) .AND. ISUP.EQ.OFF)
     2  PRINT 3550, (TPLANT(J,IPROC),J=1,3), TPLANT(BPARM,IPROC)
     3  , TPLANT(MINRV,IPROC), TPLANT(MAXRV,IPROC)
3900  CONTINUE
C
C        COMPUTE, FOR EVERY TIME PERIOD, THE OPERATING AND MAINTAINENCE
C        COSTS FOR EACH PROCESS
      DO 9500 TP = 1,MAXTP
      CALL SIZE
      CALL TRT1
      CALL TRT2
9500  CONTINUE
C
C        COMPUTE CONSTRUCTION COSTS FOR EACH PROCESS
C
      CALL CONCST
C
C        END OF SUBROUTINE TRTMNT
      RETURN
      END
      SUBROUTINE TRT1
C
C        PURPOSE:
C           TRT1 COMPUTES THE OPERATING AND MAINTAINANCE MAN-HOURS
C           REQUIRED AND THE TOTAL MATERIAL AND SUPPLY COSTS.
C           NOTE: 'TRT1' IS SEPARATE FROM 'TRTMNT' ONLY TO EASE
C           COMPILATION REQUIREMENTS.
C
C           THE COSTS ARE COMPUTED FOR EACH PROCESS WHICH IS
C           BEING USED FOR THE CURRENT TREATMENT SCHEME IN
C           THE FOLLOWING MANNER:
C
C           1. COSTS WHICH DEPEND ON THE SIZE OF THE PROCESS
C             A. IF P .LE. 0., THEN COST=F(B)
C             B. IF TP .LT. TPFADD, THEN COST=0.
C             C. IF TP .GE. TPFADD, THE COST=F(P+B)-F(P)
C
C           2. COSTS WHICH DEPEND ON ACTUAL USAGE
C             A. IF P .LE. 0., THEN COST=F(W)
C             B. OTHERWISE, COST=F(W)-F(WO)
C
C           P = PPARM = PRESENT SIZE OF PROCESS
C           B = BPARM = SIZE REQUIRED TO BE BUILT BY
C                       TIME PERIOD 'TPFADD'
C           W = WPARM = SIZE REQUIRED WITH PHOS. REMOVAL
C           WO = WOPARM = SIZE REQUIRED WITHOUT PHOS. REMOVAL
C
C        COMMON BLOCKS:
C           LIQUID - LIQUID INFLUENT INFORMATION
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           SCHEME - INFO ABOUT LIQUID TREATMNET SCHEMES
C           SEWPOP - THE SEWERED POPULATION
C           SLCHAR - SLUDGE, LIQUID, CHEMICAL CHARACTERISTICS
C           TIME   - PARAMETERS OF TIME HORIZON
C           TPLANT - CHARACTERISTICS OF TREATMENT PLANT PROCESS
C           TRTCST - TREATMENT COSTS
C
C        CALLED BY:
C           TRTMNT
C
C        AUTHOR:
C           DAVID A. BARNES 25 JAN 73
C
C        -------------------------------------------------------------
C
      COMMON /LIQUID/ ALKIPS, BODIPS, MLSSAR, NH3IAR, PINPS, QAVE
     1               , QPEAK, SSINPS, TBODAR
C
      REAL MLSSAR, NH3IAR
C
      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY
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```
      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
     1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
     2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
     3 , ALTEMF, FCTEMF, ALFBAS, FCFBAS, L1FBAS, L2FBAS, NONE
     4 , EQUIP(45)

      INTEGER ELGBTY, EQUIP, SCHEME
      INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
     1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTEMF, FCTEMF, ALFBAS
     2 , FCFBAS
      REAL MINEFP

      COMMON /SEWPOP/ FNCTYP, SPOPIN(2,5), SEWPOP(20)
     1 , YEAR, SPOP, MAXPV

      INTEGER YEAR, SPOP, FNCTYP

      COMMON /SLCHAR/    ADDSSR, ALKIAR, FCVFD , LBNVPS, LBNVSS
     1 , LBNVTS, LBVPS , LBVSS , LBVTS , LIMEPD, LMVFD , PALUM
     2 , PCO2  , PFECL , PNAAL , PNAOH , PCLYC , PPCKL , QPSLGE
     3 , QSSLGE, QTOTAL, QTSLGE, SRCAT , SRLIME, TLBNVS, TLBPS
     4 , TLBSLG, TLBSS , TLBTS , TLBVS , WCLBSS, WOPALM, WOPCO2
     5 , WOPFC , WOPLIM, WOPNAL, WOPNOH, WOPPLY, WOPPCK, WRCAT
     6 , PLIME , PYFTD , PYVFD , PPOLY , SRALF , SRCATA, WRALF
     7 , SRFEF , WRFEF , SRFEP , SRALP , WRALP , WRFEP , WRALA
     8 , WRFEA , AARATO, FERATO, SRCATS, WRCATS, WRALS , WRFES
     9 , CO2D  , SRTLIM, TSETUD, LIMETD, BODIAR, WOTLBS

      REAL        LBNVPS, LBNVSS, LBNVTS, LBVPS , LBVSS , LBVTS
     1 , LIMEPD, LMVFD , LIMETD

      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP

      COMMON /TPLANT/ TPLANT(16,45)
     1 , RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHAER, FLCCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGOCN, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
     6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     8 , WVAR  , BPARM , BASE  , APVAR , PARMX , MINRV , MAXRV
     9 , MAXP

      INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
     1 , DIFAIR, FLCCCP, SECSET, RE1PMP, CLFEED, CLBASN, RE2PMP
     2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
     3 , CENFUG, FBINC , WSPOND, SLGCCN, RECRB1, RECRB2, TERST1
     4 , TERST2, ALUMFS, FECLFS, POLYFS, CO2FS , PCKLFS, RECALC
     5 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     6 , WVAR  , BPARM , FLOCCT, BASE  , APVAR , PARMX

      COMMON /TRTCST/ OMHRS(45,20), MMHRS(45,20), TMS(45,20), CONCOS(45)
     1                , AMCOST(45), TPFADD(45)

      REAL MMHRS
      INTEGER TPFADD


C
C         OPERATION, MAITAINANCE, AND SUPPLY STATEMENT FUNCTIONS
C         FOR EACH PROCESS:
C            1. LETTER 1 OF THE FUNCTION NAME DESIGNATES THE KIND OF
C            FUNCTION-
C            O = ANNUAL OPERATING MAN-HOURS
C            A = MAINTAINANCE MAN-HOURS
C            S = SUPPLY COSTS (JAN 71 $)
C            E = ELECTRICAL COSTS (JAN 71 $)
C            C = CHEMICAL COSTS
C            T = TOTAL MATERIAL AND SUPPLY COSTS (JAN 71 $)
C            2. LETTERS 2 THRU 6 DESIGNATE THE PROCESS.
C
C         RAW WASTEWATER PUMPING
      ORWPMP(Y) = EXP(6.097269+.253066*ALOG(Y)-.193659*ALOG(Y)**2
     1            +.078201*ALOG(Y)**3-.006680*ALOG(Y)**4)
      ARWPMP(Y) = EXP(5.911541-.013158*ALOG(Y)+.076643*ALOG(Y)**2)
      ERWPMP(Y) = EXP(6.799199+.785690*ALOG(Y)+.087865*ALOG(Y)**2
     1            -.042646*ALOG(Y)**3-.004488*ALOG(Y)**4)
      SRWPMP(Y) = EXP(5.851743+.301610*ALOG(Y)+.197183*ALOG(Y)**2
     1            -.017962*ALOG(Y)**3)
C         PRE-TREATMENT
      OPRTRT(Y) = EXP(6.398716+.230956*ALOG(Y)+.164959*ALOG(Y)**2
     1            -.014601*ALOG(Y)**3)
      APRTRT(Y) = EXP(5.846098+.206513*ALOG(Y)+.068842*ALOG(Y)**2
     1            +.023824*ALOG(Y)**3-.004410*ALOG(Y)**4)
      TPRTRT(Y) = EXP(7.235657+.399935*ALOG(Y)-.224979*ALOG(Y)**2
     1            +.110099*ALOG(Y)**3-.011026*ALOG(Y)**4)
C         PRIMARY SETTLER
      OPRMST(Y) = EXP(5.846565+.254813*[illegible](Y)+.113703*ALOG(Y)**2
     1            -.010942*ALOG(Y)**3)
      APRMST(Y) = EXP(5.273419+.228329*ALOG(Y)+.122646*ALOG(Y)**2
     1            -.011672*ALOG(Y)**3)
      TPRMST(Y) = EXP(5.669881+.750799*ALOG(Y))
C         PRIMARY SLUDGE PUMPING
      OPSPMP(Y) = EXP(4.941555+.419391*ALOG(Y))
      APSPMP(Y) = EXP(3.993365+.444966*ALOG(Y))
      TPSPMP(Y) = EXP(4.433129+.642272*ALOG(Y))
C         TRICKLING FILTER
      OTRKFT(Y) = EXP(4.536510-.095731*ALOG(Y)+.173718*ALOG(Y)**2
     1            -.010114*ALOG(Y)**3)
      ATRKFT(Y) = EXP(4.312739-.052122*ALOG(Y)+.157473*ALOG(Y)**2
     1            -.010245*ALOG(Y)**3)
      TTRKFT(Y) = EXP(5.105946+.465100*ALOG(Y))
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C        AERATION BASIN
      OAERBN(Y) = 0.
      AAERBN(Y) = 0.
      TAERBN(Y) = 0.
C        DIFFUSED AIR SYSTEM
      ODIFAR(Y) = EXP(6.900586+.323725*ALOG(Y)+.059093*ALOG(Y)**2
     1            -.004926*ALOG(Y)**3)
      ADIFAR(Y) = EXP(6.169937+.294853*ALOG(Y)+.175999*ALOG(Y)**2
     1            -.040947*ALOG(Y)**3+.003300*ALOG(Y)**4)
      TDIFAR(Y) = EXP(1.999679+.703839*ALOG(Y)+.010214*ALOG(Y)**2)
     1 *1000.
C        MECHANICAL AERATION
      OMCHAR(Y) = EXP(6.716272-.310684*ALOG(Y)+.112744*ALOG(Y)**2
     1            -.004877*ALOG(Y)**3)
      AMCHAR(Y) = EXP(4.251092+.467681*ALOG(Y)+.008276*ALOG(Y)**2)
      TMCHAR(Y) = EXP(1.826687+.695104*ALOG(Y)+.011681*ALOG(Y)**2)
     1 *1000.
C        FLOCCULATION BASIN BEFORE PRIMARY
C        ASSUME: MATERIAL & SUPPLY COSTS = .2 OF M&S FOR MCHAER
C        NO DATA FOR OPERATION AND MAINTAINENCE
      OFLCCP(Y) = 0.
      AFLCCP(Y) = 0.
      TFLCCP(Y) = .2*EXP(1.826687+.695104*ALOG(Y)+.011681*ALOG(Y)**2)
     1 *1000.
C        SECONDARY SETTLER
      OSECST(Y) = EXP(5.846565+.254813*ALOG(Y)+.113703*ALOG(Y)**2
     1            -.010942*ALOG(Y)**3)
      ASECST(Y) = EXP(5.273419+.228329*ALOG(Y)+.122646*ALOG(Y)**2
     1            -.011672*ALOG(Y)**3)
      TSECST(Y) = EXP(5.669881+.750799*ALOG(Y))
C        RECIRCULATION PUMPING
      OR1PMP(Y) = EXP(6.097269+.253066*ALOG(Y)-.193659*ALOG(Y)**2
     1            -.078201*ALOG(Y)**3-.00680*ALOG(Y)**4)
      AR1PMP(Y) = EXP(5.911541-.013158*ALOG(Y)+.076643*ALOG(Y)**2)
      ER1PMP(Y) = EXP(6.799199+.785690*ALOG(Y)+.087865*ALOG(Y)**2
     1            -.042646*ALOG(Y)**3-.004488*ALOG(Y)**4)
      SR1PMP(Y) = EXP(5.851743+.301610*ALOG(Y)+.197183*ALOG(Y)**2
     1            -.017962*ALOG(Y)**3)
C        CHLORINATION FEED SYSTEM
      OCLFED(Y) = EXP(4.538517+.543665*ALOG(Y))
      ACLFED(Y) = EXP(3.752071-.224812*ALOG(Y)+.158849*ALOG(Y)**2
     1            -.006064*ALOG(Y)**3)
      TCLFED(Y) = EXP(6.620760+.468834*ALOG(Y)+.043642*ALOG(Y)**2
     1            -.002016*ALOG(Y)**3)
C        CHLORINATION BASIN
      OCLBSN(Y) = 0.
      ACLBSN(Y) = 0.
      TCLBSN(Y) = 0.
C        MULTI-MEDIA FILTER
      CMULFT(Y) = EXP(6.476972+.586929*ALOG(Y))
      AMULFT(Y) = 0.
      TMULFT(Y) = EXP(7.648428+.772694*ALOG(Y)+.015475*ALOG(Y)**2
     1            +.003726*ALOG(Y)**3-.000852*ALOG(Y)**4)
C        RECIRCULATION PUMPING
      OR2PMP(Y) = EXP(6.097269+.253066*ALOG(Y)-.193659*ALOG(Y)**2
     1              +.078201*ALOG(Y)**3-.006680*ALOG(Y)**4)
      AR2PMP(Y) = EXP(5.911541-.013158*ALOG(Y)+.076643*ALOG(Y)**2)
      ER2PMP(Y) = EXP(6.799199+.785690*ALOG(Y)+.087865*ALOG(Y)**2
     1              -.042646*ALOG(Y)**3-.004488*ALOG(Y)**4)
      SR2PMP(Y) = EXP(5.851743+.301610*ALOG(Y)+.197183*ALOG(Y)**2
     1              -.017962*ALOG(Y)**3)
C          GRAVITY THICKENER
      OGRVTK(Y) = EXP(5.846565+.254813*ALOG(Y)+.113703*ALOG(Y)**2
     1              -.010942*ALOG(Y)**3)
      AGRVTK(Y) = EXP(5.273419+.228329*ALOG(Y)+.122646*ALOG(Y)**2
     1              -.011672*ALOG(Y)**3)
      TGRVTK(Y) = EXP(5.669891+.750799*ALOG(Y))
C          AIR FLOTATION THICKENER
      OFLOTK(Y) = EXP(4.992517-.325053*ALOG(Y)+.084026*ALOG(Y)**2)
      AFLOTK(Y) = EXP(4.832373-.336504*ALOG(Y)+.083020*ALOG(Y)**2)
      EFLOTK(Y) = (EXP(-1.254959+.852347*ALOG(Y)))*365.*.7457*ELECOS
     1               *HPDFT
C          ANAEROBIC DIGESTION
      OANDIG(Y) = EXP(9.129250-1.816736*ALOG(Y)+.373282*ALOG(Y)**2
     1              -.017290*ALOG(Y)**3)
      AANDIG(Y) = EXP(8.566752-1.768137*ALOG(Y)+.363173*ALOG(Y)**2
     1              -.016620*ALOG(Y)**3)
      TANDIG(Y) = EXP(8.702803-1.182711*ALOG(Y)+.282691*ALOG(Y)**2
     1              -.013672*ALOG(Y)**3)
C          AEROBIC DIGESTION
C---       NO DATA FOR AERDIG
      OARDIG(Y) = 0.
      AARDIG(Y) = 0.
      TARDIG(Y) = 0.

C          **************************************************************
C          ****************                              ****************
C          ****************     START EXECUTION          ****************
C          ****************                              ****************
C          **************************************************************
C
1000  CONTINUE
      POPR = SEWPOP(TP)/SEWPOP(1)
C          RAW WASTEWATER PUMPING
      IF (EQUIP(RWPUMP) .EQ. OFF)  GO TO 3200
      IF (TPLANT(PPARM,RWPUMP) .GT. 0.)  GO TO 3130
      OMHRS(RWPUMP,TP) = ORWPMP(TPLANT(BPARM,RWPUMP))*TPSIZE
      MMHRS(RWPUMP,TP) = ARWPMP(TPLANT(BPARM,RWPUMP))*TPSIZE
      TMS  (RWPUMP,TP) = (ERWPMP(QAVE*POPR)+SRWPMP(QAVE*POPR))*TPSIZE
      GO TO 3200
3130  TMS(RWPUMP,TP) = 0.
      OMHRS(RWPUMP,TP) = 0.
      MMHRS(RWPUMP,TP) = 0.
      IF (TP .LT. TPFADD(RWPUMP))  GO TO 3200
      OMHRS(RWPUMP,TP) = (ORWPMP(TPLANT(PPARM,RWPUMP)
     1 +TPLANT(BPARM,RWPUMP)) -ORWPMP(TPLANT(PPARM,RWPUMP)))*TPSIZE
      MMHRS(RWPUMP,TP) = (ARWPMP(TPLANT(PPARM,RWPUMP)
     1 +TPLANT(BPARM,RWPUMP)) -ARWPMP(TPLANT(PPARM,RWPUMP)))*TPSIZE
C
C          PRE-TREATMENT
```

```
3200  CONTINUE
      IF (EQUIP(PRETRT) .EQ. OFF)  GO TO 3300
      IF (TPLANT(PPARM,PRETRT) .GT. 0.)  GO TO 3230
      OMHRS(PRETRT,TP) = OPRTRT(QAVE*POPR)*TPSIZE
      MMHRS(PRETRT,TP) = APRTRT(QAVE*POPR)*TPSIZE
      TMS  (PRETRT,TP) = TPRTRT(QAVE*POPR)*TPSIZE
      GO TO 3300
3230  OMHRS(PRETRT,TP) = 0.
      MMHRS(PRETRT,TP) = 0.
      TMS  (PRETRT,TP) = 0.
C
C        PRIMARY SETTLER
3300  CONTINUE
      IF (EQUIP(PRMSET) .EQ. OFF)  GO TO 3400
      IF (TPLANT(PPARM,PRMSET) .GT. 0.)  GO TO 3330
      OMHRS(PRMSET,TP) = OPRMST(TPLANT(BPARM,PRMSET))*TPSIZE
      MMHRS(PRMSET,TP) = APRMST(TPLANT(BPARM,PRMSET))*TPSIZE
      TMS  (PRMSET,TP) = TPRMST(TPLANT(BPARM,PRMSET))*TPSIZE
      GO TO 3400
3330  OMHRS(PRMSET,TP) = 0.
      MMHRS(PRMSET,TP) = 0.
      TMS  (PRMSET,TP) = 0.
      IF (TP .LT. TPEADD(PRMSET))  GO TO 3400
      OMHRS(PRMSET,TP) = (OPRMST(TPLANT(PPARM,PRMSET)
     1 +TPLANT(BPARM,PRMSET)) -OPRMST(TPLANT(PPARM,PRMSET)))*TPSIZE
      MMHRS(PRMSET,TP) = (APRMST(TPLANT(PPARM,PRMSET)
     1 +TPLANT(BPARM,PRMSET)) -APRMST(TPLANT(PPARM,PRMSET)))*TPSIZE
      TMS  (PRMSET,TP) = (TPRMST(TPLANT(PPARM,PRMSET)
     1 +TPLANT(BPARM,PRMSET)) -TPRMST(TPLANT(PPARM,PRMSET)))*TPSIZE
C
C        PRIMARY SLUDGE PUMPING
3400  CONTINUE
      IF (EQUIP(PSPUMP) .EQ. OFF)  GO TO 3500
      IF (TPLANT(PPARM,PSPUMP) .GT. 0.)  GO TO 3430
      OMHRS(PSPUMP,TP) = OPSPMP(TPLANT(BPARM,PSPUMP))*TPSIZE
      MMHRS(PSPUMP,TP) = APSPMP(TPLANT(BPARM,PSPUMP))*TPSIZE
      TMS  (PSPUMP,TP) = TPSPMP(TPLANT(BPARM,PSPUMP))*TPSIZE
      GO TO 3500
3430  OMHRS(PSPUMP,TP) = 0.
      MMHRS(PSPUMP,TP) = 0.
      TMS  (PSPUMP,TP) = 0.
      IF (TP .LT. TPEADD(PSPUMP))  GO TO 3500
      OMHRS(PSPUMP,TP) = (OPSPMP(TPLANT(PPARM,PSPUMP)
     1 +TPLANT(BPARM,PSPUMP)) -OPSPMP(TPLANT(PPARM,PSPUMP)))*TPSIZE
      MMHRS(PSPUMP,TP) = (APSPMP(TPLANT(PPARM,PSPUMP)
     1 +TPLANT(BPARM,PSPUMP)) -APSPMP(TPLANT(PPARM,PSPUMP)))*TPSIZE
      TMS  (PSPUMP,TP) = (TPSPMP(TPLANT(PPARM,PSPUMP)
     1 +TPLANT(BPARM,PSPUMP)) -TPSPMP(TPLANT(PPARM,PSPUMP)))*TPSIZE
C
C        TRICKLING FILTER
3500  CONTINUE
      IF (EQUIP(TRKFTR) .EQ. OFF)  GO TO 3600
      IF (TPLANT(PPARM,TRKFTR) .GT. 0.)  GO TO 3530
      OMHRS(TRKFTR,TP) = OTRKFT(TPLANT(BPARM,TRKFTR)/6.)*TPSIZE
      MMHRS(TRKFTR,TP) = ATRKFT(TPLANT(BPARM,TRKFTR)/6.)*TPSIZE
      TMS  (TRKFTR,TP) = TTRKFT(TPLANT(BPARM,TRKFTR)/6.)*TPSIZE
      GO TO 3600
 3530 OMHRS(TRKFTR,TP) =0.
      MMHRS(TRKFTR,TP) = 0.
      TMS  (TRKFTR,TP) = 0.
      IF (TP .LT. TPFADD(TRKFTR))  GO TO 3600
      OMHRS(TRKFTR,TP) = (OTRKFT(TPLANT(PPARM,TRKFTR)/6.
     1 +TPLANT(BPARM,TRKFTR)/6.)-OTRKFT(TPLANT(PPARM,TRKFTR)/6.))*TPSIZE
      MMHRS(TRKFTR,TP) = (ATRKFT(TPLANT(PPARM,TRKFTR)/6.
     1 +TPLANT(BPARM,TRKFTR)/6.)-ATRKFT(TPLANT(PPARM,TRKFTR)/6.))*TPSIZE
      TMS  (TRKFTR,TP) = (TTRKFT(TPLANT(PPARM,TRKFTR)/6.
     1 +TPLANT(BPARM,TRKFTR)/6.)-TTRKFT(TPLANT(PPARM,TRKFTR)/6.))*TPSIZE
C
C        AERATION BASIN
 3600 CONTINUE
      IF (EQUIP(AERBSN) .EQ. OFF)  GO TO 3700
      OMHRS(AERBSN,TP) = OAERBN(TPLANT(BPARM,AERBSN))*TPSIZE
      MMHRS(AERBSN,TP) = AAERBN(TPLANT(BPARM,AERBSN))*TPSIZE
      TMS  (AERBSN,TP) = TAERBN(TPLANT(BPARM,AERBSN))*TPSIZE
C
C        DIFFUSED AIR SYSTEM
 3700 CONTINUE
      IF (EQUIP(DIFAIR) .EQ. OFF)  GO TO 3800
      IF (TPLANT(PPARM,DIFAIR) .GT. 0.)  GO TO  3730
      OMHRS(DIFAIR,TP) = ODIFAR(TPLANT(BPARM,DIFAIR))*TPSIZE
      MMHRS(DIFAIR,TP) = ADIFAR(TPLANT(BPARM,DIFAIR))*TPSIZE
      TMS  (DIFAIR,TP) = TDIFAR(QAVE*POPR)*TPSIZE
      GO TO 3800
 3730 OMHRS(DIFAIR,TP) = 0.
      MMHRS(DIFAIR,TP) = 0.
      TMS  (DIFAIR,TP) = 0.
      IF (TP .LT. TPFADD(DIFAIR))  GO TO 3800
      OMHRS(DIFAIR,TP) = (ODIFAR(TPLANT(PPARM,DIFAIR)
     1 +TPLANT(BPARM,DIFAIR)) -ODIFAR(TPLANT(PPARM,DIFAIR)))*TPSIZE
      MMHRS(DIFAIR,TP) = (ADIFAR(TPLANT(PPARM,DIFAIR)
     1 +TPLANT(BPARM,DIFAIR)) -ADIFAR(TPLANT(PPARM,DIFAIR)))*TPSIZE
C
C        MECHANICAL AERATION
 3800 CONTINUE
      IF (EQUIP(MCHAER) .EQ. OFF)  GO TO 3900
      IF (TPLANT(PPARM,MCHAER) .GT. 0.)  GO TO 3830
      OMHRS(MCHAER,TP) = OMCHAR(TPLANT(BPARM,MCHAER))*TPSIZE
      MMHRS(MCHAER,TP) = AMCHAR(TPLANT(BPARM,MCHAER))*TPSIZE
      TMS  (MCHAER,TP) = TMCHAR(QAVE*POPR)*TPSIZE
      GO TO 3900
 3830 OMHRS(MCHAER,TP) = 0.
      MMHRS(MCHAER,TP) = 0.
      TMS  (MCHAER,TP) = 0.
      IF (TP .LT. TPFADD(MCHAER))  GO TO 3900
      OMHRS(MCHAER,TP) = (OMCHAR(TPLANT(PPARM,MCHAER)
     1 +TPLANT(BPARM,MCHAER)) -OMCHAR(TPLANT(PPARM,MCHAER)))*TPSIZE
      MMHRS(MCHAER,TP) = (AMCHAR(TPLANT(PPARM,MCHAER)
     1 +TPLANT(BPARM,MCHAER)) -AMCHAR(TPLANT(PPARM,MCHAER)))*TPSIZE
C
C        FLOCCULATION BEFORE PRIMARY
```

```
3900  CONTINUE
      IF (EQUIP(FLOCCP) .EQ. OFF)  GO TO 4000
      IF (TPLANT(PPARM,FLOCCP) .GT. 0.)  GO TO 3930
      OMHRS(FLOCCP,TP) = OFLCCP(TPLANT(BPARM,FLOCCP))*TPSIZE
      MMHRS(FLOCCP,TP) = AFLCCP(TPLANT(BPARM,FLOCCP))*TPSIZE
      TMS  (FLOCCP,TP) = TFLCCP(QAVE*POPR)*TPSIZE
      GO TO 4000
 3930 OMHRS(FLOCCP,TP) = 0.
      MMHRS(FLOCCP,TP) = 0.
      TMS  (FLOCCP,TP) = 0.
      IF (TP .LT. TPFADD(FLOCCP))  GO TO 4000
      OMHRS(FLOCCP,TP) = (OFLCCP(TPLANT(PPARM,FLOCCP)
     1 +TPLANT(BPARM,FLOCCP)) -OFLCCP(TPLANT(PPARM,FLOCCP)))*TPSIZE
      MMHRS(FLOCCP,TP) = (AFLCCP(TPLANT(PPARM,FLOCCP)
     1 +TPLANT(BPARM,FLOCCP)) -AFLCCP(TPLANT(PPARM,FLOCCP)))*TPSIZE
C
C         SECONDARY SETTLER
 4000 CONTINUE
      IF (EQUIP(SECSET) .EQ. OFF)  GO TO 4100
      IF (TPLANT(PPARM,SECSET) .GT. 0.)  GO TO 4030
      OMHRS(SECSET,TP) = OSECST(TPLANT(BPARM,SECSET))*TPSIZE
      MMHRS(SECSET,TP) = ASECST(TPLANT(BPARM,SECSET))*TPSIZE
      TMS  (SECSET,TP) = TSECST(TPLANT(BPARM,SECSET))*TPSIZE
      GO TO 4100
 4030 OMHRS(SECSET,TP) = 0.
      MMHRS(SECSET,TP) = 0.
      TMS  (SECSET,TP) = 0.
      IF (TP .LT. TPFADD(SECSET))  GO TO 4100
      OMHRS(SECSET,TP) =(OSECST(TPLANT(PPARM,SECSET)
     1 +TPLANT(BPARM,SECSET))-OSECST(TPLANT(PPARM,SECSET)))*TPSIZE
      MMHRS(SECSET,TP) = (ASECST(TPLANT(PPARM,SECSET)
     1 +TPLANT(BPARM,SECSET))-ASECST(TPLANT(PPARM,SECSET)))*TPSIZE
      TMS  (SECSET,TP) = (TSECST(TPLANT(PPARM,SECSET)
     1 +TPLANT(BPARM,SECSET))-TSECST(TPLANT(PPARM,SECSET)))*TPSIZE
C
C         RECIRCULATION PUMPING
 4100 CONTINUE
      IF (EQUIP(RE1PMP) .EQ. OFF)  GO TO 4200
      IF (TPLANT(PPARM,RE1PMP) .GT. 0.)  GO TO 4130
      OMHRS(RE1PMP,TP) = OR1PMP(TPLANT(BPARM,RE1PMP))*TPSIZE
      MMHRS(RE1PMP,TP) = AR1PMP(TPLANT(BPARM,RE1PMP))*TPSIZE
      TMS  (RE1PMP,TP) = (ER1PMP(QAVE*POPR)+SR1PMP(QAVE*POPR))*TPSIZE
      GO TO 4200
 4130 OMHRS(RE1PMP,TP) = 0.
      MMHRS(RE1PMP,TP) = 0.
      TMS  (RE1PMP,TP) = 0.
      IF (TP .LT. TPFADD(RE1PMP))  GO TO 4200
      OMHRS(RE1PMP,TP) = (OR1PMP(TPLANT(PPARM,RE1PMP)
     1 +TPLANT(BPARM,RE1PMP)) -OR1PMP(TPLANT(PPARM,RE1PMP)))*TPSIZE
      MMHRS(RE1PMP,TP) = (AR1PMP(TPLANT(PPARM,RE1PMP)
     1 +TPLANT(BPARM,RE1PMP)) -AR1PMP(TPLANT(PPARM,RE1PMP)))*TPSIZE
C
C         CHLORINE FEED SYSTEM
 4200 CONTINUE
      IF (EQUIP(CLFFED) .EQ. OFF)  GO TO 4300
      IF (TPLANT(PPARM,CLFEED) .GT. 0.)  GO TO 4230
      W = QAVE*POPR*TPLANT(WVAR,CLFEED)*365.*8.33/2000.
      P = QAVE*POPR*TPLANT(PVAR,CLFEED)*365.*8.33/2000.
      OMHRS(CLFEED,TP) = OCLFED(W)*TPSIZE
      MMHRS(CLFEED,TP) = ACLFED(W)*TPSIZE
      TMS  (CLFEED,TP) = TCLFED(W)*TPSIZE
      GO TO 4300
 4230 OMHRS(CLFEED,TP) = 0.
      MMHRS(CLFEED,TP) = 0.
      TMS  (CLFEED,TP) = 0.
C
C        CHLORINATION CONTACT BASIN
 4300 CONTINUE
      IF (EQUIP(CLBASN) .EQ. OFF)  GO TO 4400
      OMHRS(CLBASN,TP) = OCLBSN(TPLANT(BPARM,CLBASN))*TPSIZE
      MMHRS(CLBASN,TP) = ACLBSN(TPLANT(BPARM,CLBASN))*TPSIZE
      TMS  (CLBASN,TP) = TCLBSN(TPLANT(BPARM,CLBASN))*TPSIZE
C
C        MULTI-MEDIA FILTER
 4400 CONTINUE
      IF (EQUIP(MULFTR) .EQ. OFF)  GO TO 4500
      IF (TPLANT(PPARM,MULFTR) .GT. 0.)  GO TO 4430
      OMHRS(MULFTR,TP) = OMULFT(TPLANT(BPARM,MULFTR))*TPSIZE
      MMHRS(MULFTR,TP) = AMULFT(TPLANT(BPARM,MULFTR))*TPSIZE
      TMS  (MULFTR,TP) = TMULFT(TPLANT(BPARM,MULFTR))*TPSIZE
      GO TO 4500
 4430 OMHRS(MULFTR,TP) = 0.
      MMHRS(MULFTR,TP) = 0.
      TMS  (MULFTR,TP) = 0.
      IF (TP .LT. TPFADD(MULFTR))  GO TO 4500
      OMHRS(MULFTR,TP) = (OMULFT(TPLANT(PPARM,MULFTR)
     1 +TPLANT(BPARM,MULFTR)) -OMULFT(TPLANT(PPARM,MULFTR)))*TPSIZE
      MMHRS(MULFTR,TP) = (AMULFT(TPLANT(PPARM,MULFTR)
     1 +TPLANT(BPARM,MULFTR)) -AMULFT(TPLANT(PPARM,MULFTR)))*TPSIZE
      TMS  (MULFTR,TP) = (TMULFT(TPLANT(PPARM,MULFTR)
     1 +TPLANT(BPARM,MULFTR)) -TMULFT(TPLANT(PPARM,MULFTR)))*TPSIZE
C
C        RECIRCULATION PUMPING
 4500 CONTINUE
      IF (EQUIP(RE2PMP) .EQ. OFF)  GO TO 4600
      IF (TPLANT(PPARM,RE2PMP) .GT. 0.)  GO TO 4530
      OMHRS(RE2PMP,TP) = OR2PMP(TPLANT(BPARM,RE2PMP))*TPSIZE
      MMHRS(RE2PMP,TP) = AR2PMP(TPLANT(BPARM,RE2PMP))*TPSIZE
      TMS  (RE2PMP,TP) = (ER2PMP(QAVE*POPR)+SR2PMP(QAVE*POPR))*TPSIZE
      GO TO 4600
 4530 OMHRS(RE2PMP,TP) = 0.
      MMHRS(RE2PMP,TP) = 0.
      TMS  (RE2PMP,TP) = 0.
      IF (TP .LT. TPFADD(RE2PMP))  GO TO 4600
      OMHRS(RE2PMP,TP) = (OR2PMP(TPLANT(PPARM,RE2PMP)
     1 +TPLANT(BPARM,RE2PMP)) -OR2PMP(TPLANT(PPARM,RE2PMP)))*TPSIZE
      MMHRS(RE2PMP,TP) = (AR2PMP(TPLANT(PPARM,RE2PMP)
     1 +TPLANT(BPARM,RE2PMP)) -AR2PMP(TPLANT(PPARM,RE2PMP)))*TPSIZE
C
C        GRAVITY THICKENER
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4600  CONTINUE
      IF (EQUIP(GRVTKN) .EQ. OFF)  GO TO 4700
      IF (TPLANT(PPARM,GRVTKN) .GT. 0.)  GO TO 4630
      OMHRS(GRVTKN,TP) = OGRVTK(TPLANT(BPARM,GRVTKN))*TPSIZE
      MMHRS(GRVTKN,TP) = AGRVTK(TPLANT(BPARM,GRVTKN))*TPSIZE
      TMS  (GRVTKN,TP) = TGRVTK(TPLANT(BPARM,GRVTKN))*TPSIZE
      GO TO 4700
4630  OMHRS(GRVTKN,TP) = 0.
      MMHRS(GRVTKN,TP) = 0.
      TMS  (GRVTKN,TP) = 0.
      IF (TP .LT. TPFADD(GRVTKN))  GO TO 4700
      OMHRS(GRVTKN,TP) = (OGRVTK(TPLANT(PPARM,GRVTKN)
     1 +TPLANT(BPARM,GRVTKN)) -OGRVTK(TPLANT(PPARM,GRVTKN)))*TPSIZE
      MMHRS(GRVTKN,TP) = (AGRVTK(TPLANT(PPARM,GRVTKN)
     1 +TPLANT(BPARM,GRVTKN)) -AGRVTK(TPLANT(PPARM,GRVTKN)))*TPSIZE
      TMS  (GRVTKN,TP) = (TGRVTK(TPLANT(PPARM,GRVTKN)
     1 +TPLANT(BPARM,GRVTKN)) -TGRVTK(TPLANT(PPARM,GRVTKN)))*TPSIZE
C
C         AIR FLOTATION THICKENER
4700  CONTINUE
      IF (EQUIP(FLOTKN) .EQ. OFF)  GO TO 4800
      IF (TPLANT(PPARM,FLOTKN) .GT. 0.)  GO TO 4730
      OMHRS(FLOTKN,TP) = OFLOTK(TPLANT(BPARM,FLOTKN))*TPSIZE
      MMHRS(FLOTKN,TP) = AFLOTK(TPLANT(BPARM,FLOTKN))*TPSIZE
      TMS  (FLOTKN,TP) = (EFLOTK(TPLANT(BPARM,FLOTKN))
     1                        +TLBSS*365./2000.*PYFTD
     2                   *TPLANT(PVAR,POLYFS))*TPSIZE
      GO TO 4800
4730  OMHRS(FLOTKN,TP) = 0.
      MMHRS(FLOTKN,TP) = 0.
      TMS  (FLOTKN,TP) = (0.+(TLBSS-WOLBSS))
     1                   *365./2000.*PYFTD*TPLANT(PVAR,POLYFS)*TPSIZE
      IF (TP .LT. TPFADD(FLOTKN))  GO TO 4800
      OMHRS(FLOTKN,TP) = (OFLOTK(TPLANT(PPARM,FLOTKN)
     1 +TPLANT(BPARM,FLOTKN)) -OFLOTK(TPLANT(PPARM,FLOTKN)))*TPSIZE
      MMHRS(FLOTKN,TP) = (AFLOTK(TPLANT(PPARM,FLOTKN)
     1 +TPLANT(BPARM,FLOTKN)) -AFLOTK(TPLANT(PPARM,FLOTKN)))*TPSIZE
      TMS  (FLOTKN,TP) = (EFLOTK(TPLANT(PPARM,FLOTKN)
     1 +TPLANT(BPARM,FLOTKN)) -EFLOTK(TPLANT(PPARM,FLOTKN)))*TPSIZE
     2                   +TMS(FLOTKN,TP)
C
C         ANAEROBIC DIGESTION
4800  CONTINUE
      IF (EQUIP(ANADIG) .EQ. OFF)  GO TO 4900
      IF (TPLANT(PPARM,ANADIG) .GT. 0.)  GO TO 4830
      OMHRS(ANADIG,TP) = OANDIG(TPLANT(BPARM,ANADIG))*TPSIZE
      MMHRS(ANADIG,TP) = AANDIG(TPLANT(BPARM,ANADIG))*TPSIZE
      TMS  (ANADIG,TP) = TANDIG(TPLANT(BPARM,ANADIG))*TPSIZE
      GO TO 4900
4830  OMHRS(ANADIG,TP) = 0.
      MMHRS(ANADIG,TP) = 0.
      TMS  (ANADIG,TP) = 0.
      IF (TP .LT. TPFADD(ANADIG))  GO TO 4900
      OMHRS(ANADIG,TP) = (OANDIG(TPLANT(PPARM,ANADIG)
     1 +TPLANT(BPARM,ANADIG)) -OANDIG(TPLANT(PPARM,ANADIG)))*TPSIZE
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      MMHRS(ANADIG,TP) = (AANDIG(TPLANT(PPARM,ANADIG)
     1 +TPLANT(BPARM,ANADIG)) -AANDIG(TPLANT(PPARM,ANADIG)))*TPSIZE
      TMS  (ANADIG,TP) = (TANDIG(TPLANT(PPARM,ANADIG)
     1 +TPLANT(BPARM,ANADIG)) -TANDIG(TPLANT(PPARM,ANADIG)))*TPSIZE
C
C         AEROBIC DIGESTION
C---      NO DATA FOR AERDIG
4500  CONTINUE
      IF (EQUIP(AERDIG) .EQ. OFF)  GO TO 5000
      CMHRS(AERDIG,TP) = OARDIG(TPLANT(BPARM,AERDIG))*TPSIZE
      MMHRS(AERDIG,TP) = AARDIG(TPLANT(BPARM,AERDIG))*TPSIZE
      TMS  (AERDIG,TP) = TARDIG(TPLANT(BPARM,AERDIG))*TPSIZE
5000  CONTINUE
C
C         END OF SUBROUTINE TRT1
      RETURN
      END
      SUBROUTINE TRT2
C
C        PURPOSE:
C           TRT2 IS SIMILAR TO TRT1.
C
C        COMMON BLOCKS:
C
C        SUBROUTINES CALLED:
C
C        AUTHOR:
C           DAVID A. BARNES 25 JAN 73
C
C        ---------------------------------------------------------
C
C
      COMMON / CHMCST/ LIMECS, ALUMCS, POLYCS, FECLCS, NAALCS, PCKLCS
     1              , NAOHCS, CO2CS

      REAL LIMECS, NAALCS, NAOHCS

      COMMON /LIQUID/ ALKIPS, BODIPS, MLSSAR, NH3IAR, PINPS, QAVE
     1              , QPEAK, SSINPS, TBODAR

      REAL MLSSAR, NH3IAR

      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
     1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
     2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
     3 , ALTFMF, FCTFMF, ALFBAS, FCFBAS, L1FBAS, L2FBAS, NONE
     4 , EQUIP(45)

      INTEGER ELGBTY, EQUIP, SCHEME
      INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
     1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTFMF, FCTFMF, ALFBAS
     2 , FCFBAS
      REAL MINEFP

      COMMON /SEWPOP/ FNCTYP, SPOPIN(2,5), SEWPOP(20)
     1 , YEAR, SPOP, MAXPV

      INTEGER YEAR, SPOP, FNCTYP

      COMMON /SLCPAR/    ADDSSR, ALKIAR, FCVFD , LBNVPS, LBNVSS
     1 , LBNVTS, LBVPS , LBVSS , LBVTS , LIMEPD, LMVPD , PALUM
     2 , PCO2  , PFECL , PNAAL , PNAOH , POLYD , PPCKL , QPSLGE
     3 , QSSLGE, QTOTAL, QTSLGE, SPCAT , SPLIME, TLBNVS, TLBPS
     4 , TLBSLG, TLBSS , TLBTS , TLBVS , WCLBSS, WOPALM, WOPCO2
     5 , WOPFC , WOPLIM, WOPNAL, WOPNUM, WOPPLY, WOPPCK, WRCAT
     6 , PLIME , PYFTD , PYVFC , PPOLY , SRALF , SRCATA, WRALF
     7 , SRFEF , WRFEF , SRFEP , SRALP , WRALP , WRFEP , WRALA
     8 , WRFEA , AARATO, FRRATO, SRCATS, WRCATS, WRALS , WRFES
     9 , CO2D  , SRTLIM, TSFTUD, LIMETD, BCDIAR, WOTLBS

      REAL       LBNVPS, LBNVSS, LBNVTS, LBVPS , LBVSS , LBVTS
     1 , LIMEPC, LMVFD , LIMETD

      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP

      COMMON /TPLANT/ TPLANT(16,45)
     1 , RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHAER, FLCCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGOCN, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
     6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     8 , WVAR  , BPARM , BASE  , APVAR , PARMX , MINRV , MAXRV
     9 , MAXP

      INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
     1 , DIFAIR, FLCCCP, SECSET, RE1PMP, CLFEED, CLBASN, RE2PMP
     2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
     3 , CENFUG, FBINC , WSPOND, SLGOCN, RECRB1, RECRB2, TERST1
     4 , TERST2, ALUMFS, FECLFS, POLYFS, CO2FS , PCKLFS, RECALC
     5 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     6 , WVAR  , BPARM , FLOCCT, BASE  , APVAR , PARMX

      COMMON /TRTCST/ OMHRS(45,20), MMHRS(45,20), TMS(45,20), CONCOS(45)
     1                , AMCOST(45), TPFADD(45)

      REAL MMHRS
      INTEGER TPFADD

      COMMON /TSCST/ CNSTRC, MATRLS

      REAL MATRLS

C        SLUDGE DRYING BED
      ODRYBD(Y) = EXP(6.345052-.476780*ALOG(Y)+.101319*ALOG(Y)**2)
      ADRYBD(Y) = EXP(4.290089-.098293*ALOG(Y)+.075453*ALOG(Y)**2)
      TDRYBD(Y) = EXP(.693148+1.0*ALOG(Y))
C        SLUDGE HOLDING TANK
      OSLTNK(Y) = EXP(5.727345+.000762*ALOG(Y)+.098701*ALOG(Y)**2
     1            -.006786*ALOG(Y)**3)
      ASLTNK(Y) = EXP(4.505628+.214662*ALOG(Y)+.071402*ALOG(Y)**2
     1            -.004691*ALOG(Y)**3)
      TSLTNK(Y) = EXP(5.479939+.299282*ALOG(Y)+.106008*ALOG(Y)**2
     1            -.008656*ALOG(Y)**3)
C        VACUUM FILTER
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C        OVCFTL IS THE EQUATION FOR LANDFILL
C        OVCFTI IS THE EQUATION FOR INCINERATION
      OVCFTL(Y) = EXP(6.069419-.009894*ALOG(Y)+.042699*ALOG(Y)**2)
      OVCFTI(Y) = EXP(3.714368+.850848*ALOG(Y)-.074615*ALOG(Y)**2
     1              +.005085*ALOG(Y)**3)
      AVACFT(Y) = EXP(4.306110-.093695*ALOG(Y)+.047738*ALOG(Y)**2)
      SVACFT(Y) = EXP(-3.113515+.718466*ALOG(Y))*1000.
      CVACFT(Y) = Y*(FCVFD*FECLCS+LMVFD*LIMECS+PYVFD*POLYCS)
C        CENTRIFUGE
      OCNFGL(Y) = EXP(7.621517-.476977*ALOG(Y)+.071516*ALOG(Y)**2)
      OCNFGI(Y) = EXP(7.264153-.466246*ALOG(Y)+.069552*ALOG(Y)**2)
      ACENFG(Y) = EXP(5.997115-.493809*ALOG(Y)+.070892*ALOG(Y)**2)
      TCENFG(Y) = EXP(-2.457491+.689633*ALOG(Y)+.007989*ALOG(Y)**2)
     1 *1000.
C        MULTIPLE HEARTH INCINERATION
      OMHINC(Y) = EXP(3.402537+1.215130*ALOG(Y)-.157203*ALOG(Y)**2
     1              +.009771*ALOG(Y)**3)
      AMHINC(Y) = EXP(3.906553+.702471*ALOG(Y)-.088337*ALOG(Y)**2
     1              +.006827*ALOG(Y)**3)
      TMHINC(Y) = EXP(8.514996-.252966*ALOG(Y)+.045589*ALOG(Y)**2)
C        FLUIDIZED BED INCINERATION
C---     NO DATA FOR FBINC
      OFBINC(Y) = 0.
      AFBINC(Y) = 0.
      TFBINC(Y) = 0.
C        WASTE STABILIZATION POND
C---     NO DATA FOR WSPOND
      OWSPND(Y) = 0.
      AWSPND(Y) = 0.
      TWSPND(Y) = 0.
C        SLUDGE LAGOON
      OSLGON(Y) = EXP(6.567594-.971759*ALOG(Y)+.095689*ALOG(Y)**2)
      ASLGON(Y) = EXP(-2.087392+2.395831*ALOG(Y)-.340388*ALOG(Y)**2
     1              +.017499*ALOG(Y)**3)
      TSLGON(Y) = EXP(-3.134169+.768622*ALOG(Y)) * 1000.
C        RECARBONATION
      ORCRB1(Y) = 0.
      ARCRB1(Y) = 0.
      TRCRB1(Y) = 0.
C        RECARBONATION
      ORCRB2(Y) = 0.
      ARCRB2(Y) = 0.
      TRCRB2(Y) = 0.
C        TERTIARY SETTLER
      OTRST1(Y) = EXP(5.846565+.254813*ALOG(Y)+.113703*ALOG(Y)**2
     1              -.010942*ALOG(Y)**3)
      ATRST1(Y) = EXP(5.273419+.228329*ALOG(Y)+.122646*ALOG(Y)**2
     1              -.011672*ALOG(Y)**3)
      TTRST1(Y) = EXP(5.669881+.750799*ALOG(Y))
C        TERTIARY SETTLER
      OTRST2(Y) = EXP(5.846565+.254813*ALOG(Y)+.113703*ALOG(Y)**2
     1              -.010942*ALOG(Y)**3)
      ATRST2(Y) = EXP(5.273419+.228329*ALOG(Y)+.122646*ALOG(Y)**2
     1              -.011672*ALOG(Y)**3)
      TTRST2(Y) = EXP(5.669881+.750799*ALOG(Y))
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C          ALUM FEEDING AND STORAGE
       AALMFS(Y) = EXP(5.993043-.097218*ALOG(Y)+.039080*ALOG(Y)**2)
C          LIME FEEDING AND STORAGE
       ALIMFS(Y) = EXP(6.060054+.197073*ALOG(Y))
C          FERRIC CHLORIDE FEEDING AND STORAGE
       OFECFS(Y) = 0.
       AFECFS(Y) = EXP(5.993043-.097218*ALOG(Y)+.039080*ALOG(Y)**2)
C          POLYMER FEEDING AND STORAGE
       APLYFS(Y) = EXP(6.426929-.061443*ALOG(Y)+.033087*ALOG(Y)**2)
C          CARBON DIOXIDE FEEDING AND STORAGE
       OCO2FS(Y) = EXP(6.900586+.323725*ALOG(Y)+.059093*ALOG(Y)**2
      1            -.004926*ALOG(Y)**3)
       ACO2FS(Y) = EXP(6.169937+.294853*ALOG(Y)+.175999*ALOG(Y)**2
      1            -.040947*ALOG(Y)**3+.003300*ALOG(Y)**4)
       TCO2FS(Y) = EXP(1.999679+.703939*ALOG(Y)+.010214*ALOG(Y)**2)
      1 *1000.+CO2[illegible]=PCO2
C          SODIUM ALUMINATE FEEDING AND STORAGE
       ANALFS(Y) = .7*EXP(5.993043-.097218*ALOG(Y)+.039080*ALOG(Y)**2)
C          PICKLING LIQUOR FEEDING AND STORAGE
       OPCKFS(Y) = 0.
       APCKFS(Y) = EXP(5.993043-.097218*ALOG(Y)+.039080*ALOG(Y)**2)
C          SODIUM HYDROXIDE FEEDING AND STORAGE
C---       NO DATA FOR NAOHFS
       ONOHFS(Y) = 0.
       ANOHFS(Y) = 0.
       TNOHFS(Y) = 0.
C          RECALINATION
       ORCALC(Y) = 7.8*Y**(-.63)*Y*365.
       ARCALC(Y) = .6*Y*365.
       TRCALC(Y) = (.63+100.*ELECOS+519.*LIMECS+(10.*EXP(.28518-.10203
      1            *ALOG(Y))))*Y*365.
C          FLOCCULATION BEFORE TERTIARY
C          ASSUME: MATERIAL & SUPPLY COSTS = .2 OF M&S FOR MCHAER
C          NO DATA FOR OPERATION AND MAINTAINENCE
       OFLCCT(Y) = 0.
       AFLCCT(Y) = 0.
       TFLCCT(Y) = .2*EXP(1.826687+.695104*ALOG(Y)+.011681*ALOG(Y)**2)
      1            *1000.
C
C          **************************************************************
C          ****************                              ****************
C          ****************     START EXECUTION          ****************
C          ****************                              ****************
C          **************************************************************
C
       POPF = SEWPOP(TP) / SEWPOP(1)
       W = TLBSLG * 365. / 2000.
       WO = WOTLBS*365./2000.
C
C          SLUDGE DRYING BEDS
5000   CONTINUE
       IF (EQUIP(DRYBED) .EQ. OFF)  GO TO 5100
       IF (TPLANT(PPARM,DRYBED) .GT. 0.)  GO TO 5030
       OMHRS(DRYBED,TP) = ODRYBD(W)*TPSIZE
       MMHRS(DRYBED,TP) = ADRYBD(W)*TPSIZE
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      TMS  (DRYBED,TP) = TDRYBD(W)*TPSIZE
      GO TO 5100
 5030 OMHRS(DRYBED,TP) = (ODRYBD(W)-ODRYBD(WO))*TPSIZE
      MMHRS(DRYBED,TP) = (ADRYBD(W)-ADRYBD(WO))*TPSIZE
      TMS  (DRYBED,TP) = (TDRYBD(W)-TDRYBD(WO))*TPSIZE
C        SLUDGE HOLDING TANK
 5100 CONTINUE
      IF (EQUIP(SLDTNK) .EQ. OFF)  GO TO 5200
      IF (TPLANT(PPARM,SLDTNK) .GT. 0.)  GO TO 5130
      OMHRS(SLDTNK,TP) = OSLTNK(TPLANT(BPARM,SLDTNK))*TPSIZE
      MMHRS(SLDTNK,TP) = ASLTNK(TPLANT(BPARM,SLDTNK))*TPSIZE
      TMS  (SLDTNK,TP) = TSLTNK(TPLANT(BPARM,SLDTNK))*TPSIZE
      GO TO 5200
 5130 OMHRS(SLDTNK,TP) = 0.
      MMHRS(SLDTNK,TP) = 0.
      TMS  (SLDTNK,TP) = 0.
      IF (TP .LT. TPFADD(SLDTNK))  GO TO 5200
      OMHRS(SLDTNK,TP) = (OSLTNK(TPLANT(PPARM,SLDTNK)
     1 +TPLANT(BPARM,SLDTNK)) -OSLTNK(TPLANT(PPARM,SLDTNK)))*TPSIZE
      MMHRS(SLDTNK,TP) = (ASLTNK(TPLANT(PPARM,SLDTNK)
     1 +TPLANT(BPARM,SLDTNK)) -ASLTNK(TPLANT(PPARM,SLDTNK)))*TPSIZE
      TMS  (SLDTNK,TP) = (TSLTNK(TPLANT(PPARM,SLDTNK)
     1 +TPLANT(BPARM,SLDTNK)) -TSLTNK(TPLANT(PPARM,SLDTNK)))*TPSIZE
C
C        VACUUM FILTER
 5200 CONTINUE
      IF (EQUIP(VACFTR) .EQ. OFF)  GO TO 5300
      IF (TPLANT(PPARM,VACFTR) .GT. 0.)  GO TO 5230
      OMHRS(VACFTR,TP) = OVCFTL(W)*TPSIZE
      IF (EQUIP(MHINC) .EQ. ON .OR. EQUIP(FBINC) .EQ. ON)
     1 OMHRS(VACFTR,TP) = OVCFTI(W)*TPSIZE
      MMHRS(VACFTR,TP) = AVACFT(W)*TPSIZE
      TMS  (VACFTR,TP) = (SVACFT(W)+CVACFT(W))*TPSIZE
      GO TO 5300
 5230 OMHRS(VACFTR,TP) = (OVCFTL(W)-OVCFTL(WO))*TPSIZE
      IF (EQUIP(MHINC) .EQ. ON .OR. EQUIP(FBINC) .EQ. ON)
     1 OMHRS(VACFTR,TP) = (OVCFTI(W)-OVCFTI(WO))*TPSIZE
      MMHRS(VACFTR,TP) = (AVACFT(W)-AVACFT(WO))*TPSIZE
      TMS  (VACFTR,TP) = ((SVACFT(W)+CVACFT(W))-(SVACFT(WO)+CVACFT(WO)))
     1                  *TPSIZE
C
C        CENTRIFUGE
 5300 CONTINUE
      IF (EQUIP(CENFUG) .EQ. OFF)  GO TO 5400
      IF (TPLANT(PPARM,CENFUG) .GT. 0.)  GO TO 5330
      OMHRS(CENFUG,TP) = OCNFGL(W)*TPSIZE
      IF (EQUIP(MHINC) .EQ. ON .OR. EQUIP(FBINC) .EQ. ON)
     1 OMHRS(CENFUG,TP) = OCNFGI(W)*TPSIZE
      MMHRS(CENFUG,TP) = ACENFG(W)*TPSIZE
      TMS  (CENFUG,TP) = TCENFG(W)*TPSIZE
      GO TO 5400
 5330 OMHRS(CENFUG,TP) = (OCNFGL(W)-OCNFGL(WO))*TPSIZE
      IF (EQUIP(MHINC) .EQ. ON .OR. EQUIP(FBINC) .EQ. ON)
     1 OMHRS(CENFUG,TP) = (OCNFGI(W)-OCNFGI(WO))*TPSIZE
      MMHRS(CENFUG,TP) = (ACENFG(W)-ACENFG(WO))*TPSIZE
      TMS  (CENFUG,TP) = (TCENFG(W)-TCENFG(WO))*TPSIZE
C
C        MULTIPLE-HEARTH INCINERATION
 5400 CONTINUE
      IF (EQUIP(MHINC) .EQ. OFF)  GO TO 5500
      IF (TPLANT(PPARM,MHINC) .GT. 0.)  GO TO 5430
      OMHRS(MHINC ,TP) = OMHINC(W)*TPSIZE
      MMHRS(MHINC ,TP) = AMHINC(W)*TPSIZE
      TMS  (MHINC ,TP) = TMHINC(W)*TPSIZE
      GO TO 5500
 5430 OMHRS(MHINC ,TP) = (OMHINC(W)-OMHINC(WO))*TPSIZE
      MMHRS(MHINC ,TP) = (AMHINC(W)-AMHINC(WO))*TPSIZE
      TMS  (MHINC ,TP) = (TMHINC(W)-TMHINC(WO))*TPSIZE
C
C        FLUIDIZED-BED INCINERATION
 5500 CONTINUE
      IF (EQUIP(FBINC) .EQ. OFF)  GO TO 5600
      IF (TPLANT(PPARM,FBINC) .GT. 0.)  GO TO 5530
      OMHRS(FBINC ,TP) = OFBINC(W)*TPSIZE
      MMHRS(FBINC ,TP) = AFBINC(W)*TPSIZE
      TMS  (FBINC ,TP) = TFBINC(W)*TPSIZE
      GO TO 5600
 5530 OMHRS(FBINC ,TP) = (OFBINC(W)-OFBINC(WO))*TPSIZE
      MMHRS(FBINC ,TP) = (AFBINC(W)-AFBINC(WO))*TPSIZE
      TMS  (FBINC ,TP) = (TFBINC(W)-TFBINC(WO))*TPSIZE
C
C        WASTE STABLIZATION POND
C---     NO DATA FOR WSPOND
 5600 CONTINUE
      IF (EQUIP(WSPOND) .EQ. OFF)  GO TO 5700
      OMHRS(WSPOND,TP) = OWSPND(BP)*TPSIZE
      MMHRS(WSPOND,TP) = AWSPND(BP)*TPSIZE
      TMS  (WSPOND,TP) = TWSPND(BP)*TPSIZE
C
C        SLUDGE LAGOON
 5700 CONTINUE
      IF (EQUIP(SLGOON) .EQ. OFF)  GO TO 5800
      IF (TPLANT(PPARM,SLGOON) .GT. 0.)  GO TO 5730
      OMHRS(SLGOON,TP) = OSLGON(W)*TPSIZE
      MMHRS(SLGOON,TP) = ASLGON(W)*TPSIZE
      TMS  (SLGOON,TP) = TSLGON(W)*TPSIZE
      GO TO 5800
 5730 OMHRS(SLGOON,TP) = (OSLGON(W) - OSLGON(WO))*TPSIZE
      MMHRS(SLGOON,TP) = (ASLGON(W) - OSLGON(WO))*TPSIZE
      TMS  (SLGOON,TP) = (TSLGON(W) - TSLGON(WO))*TPSIZE
C
C        RECARBONIZATION
 5800 CONTINUE
      IF (EQUIP(RECRB1) .EQ. OFF)  GO TO 5900
      OMHRS(RECRB1,TP) = ORCRB1(TPLANT(BPARM,RECRB1))*TPSIZE
      MMHRS(RECRB1,TP) = ARCRB1(TPLANT(BPARM,RECRB1))*TPSIZE
      TMS  (RECRB1,TP) = TRCRB1(TPLANT(BPARM,RECRB1))*TPSIZE
C
C        RECARBONIZATION
 5900 CONTINUE
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      IF (EQUIP(RECRB2) .EQ. OFF)  GO TO 8000
      OMHRS(RECRB2,TP) = ORCRB2(TPLANT(BPARM,RECRB2))*TPSIZE
      MMHRS(RECRB2,TP) = ARCRB2(TPLANT(BPARM,RECRB2))*TPSIZE
      TMS  (RECRB2,TP) = TRCRB2(TPLANT(BPARM,RECRB2))*TPSIZE
C
C        TERTIARY SETTLER
 8000 CONTINUE
      IF (EQUIP(TERST1) .EQ. OFF)  GO TO 8100
      IF (TPLANT(PPARM,TERST1) .GT. 0.) GO TO 8030
      OMHRS(TERST1,TP) = OTRST1(TPLANT(BPARM,TERST1))*TPSIZE
      MMHRS(TERST1,TP) = ATRST1(TPLANT(BPARM,TERST1))*TPSIZE
      TMS  (TERST1,TP) = TTRST1(TPLANT(BPARM,TERST1))*TPSIZE
      GO TO 8100
 8030 OMHRS(TERST1,TP) = 0.
      MMHRS(TERST1,TP) = 0.
      TMS  (TERST1,TP) = 0.
      IF (TP .LT. TPFADD(TERST1))  GO TO 8100
      OMHRS(TERST1,TP) = (OTRST1(TPLANT(PPARM,TERST1)
     1 +TPLANT(BPARM,TERST1)) -OTRST1(TPLANT(PPARM,TERST1)))*TPSIZE
      MMHRS(TERST1,TP) = (ATRST1(TPLANT(PPARM,TERST1)
     1 +TPLANT(BPARM,TERST1)) -ATRST1(TPLANT(PPARM,TERST1)))*TPSIZE
      TMS  (TERST1,TP) = (TTRST1(TPLANT(PPARM,TERST1)
     1 +TPLANT(BPARM,TERST1)) -TTRST1(TPLANT(PPARM,TERST1)))*TPSIZE
C
C        TERTIARY SETTLER
 8100 CONTINUE
      IF (EQUIP(TERST2) .EQ. OFF)  GO TO 8200
      IF (TPLANT(PPARM,TERST2) .GT. 0.)  GO TO 8130
      OMHRS(TERST2,TP) = OTRST2(TPLANT(BPARM,TERST2))*TPSIZE
      MMHRS(TERST2,TP) = ATRST2(TPLANT(BPARM,TERST2))*TPSIZE
      TMS  (TERST2,TP) = TTRST2(TPLANT(BPARM,TERST2))*TPSIZE
      GO TO 8200
 8130 OMHRS(TERST2,TP) = 0.
      MMHRS(TERST2,TP) = 0.
      TMS  (TERST2,TP) = 0.
      IF (TP .LT. TPFADD(TERST2))  GO TO 8200
      OMHRS(TERST2,TP) = (OTRST2(TPLANT(PPARM,TERST2)
     1 +TPLANT(BPARM,TERST2)) -OTRST2(TPLANT(PPARM,TERST2)))*TPSIZE
      MMHRS(TERST2,TP) = (ATRST2(TPLANT(PPARM,TERST2)
     1 +TPLANT(BPARM,TERST2)) -ATRST2(TPLANT(PPARM,TERST2)))*TPSIZE
      TMS  (TERST2,TP) = (TTRST2(TPLANT(PPARM,TERST2)
     1 +TPLANT(BPARM,TERST2)) -TTRST2(TPLANT(PPARM,TERST2)))*TPSIZE
C
C        ALUM FEEDING AND STORAGE
 8200 CONTINUE
      IF (EQUIP(ALUMFS) .EQ. OFF)  GO TO 8300
      W = PALUM/5.4
      WO = WOPALM/5.4
      OMHRS(ALUMFS,TP) = 0.
      IF (TPLANT(PPARM,ALUMFS) .GT. 0.)  GO TO 8230
      MMHRS(ALUMFS,TP) = 600.*TPSIZE
      IF (W .GT. 100.)  MMHRS(ALUMFS,TP) = AALMFS(W)*TPSIZE
      TMS  (ALUMFS,TP) = PALUM*TPLANT(WVAR,ALUMFS)*365.*TPSIZE
      GO TO 8300
 8230 MMHRS(ALUMFS,TP) = (AALMFS(W)-AALMFS(WO))*TPSIZE
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      TMS  (ALUMFS,TP) = (PALUM*TPLANT(WVAR,ALUMFS)
     1                   -WOPALM*TPLANT(PVAR,ALUMFS))*365.*TPSIZE
C
C        LIME FEEDING AND STORAGE
8300  CONTINUE
      IF (EQUIP(LIMEFS) .EQ. OFF)  GO TO 8400
      W = PLIME
      WC= WOPLIM
      CMHRS(LIMEFS,TP) = 0.
      IF (TPLANT(PPARM,LIMEFS) .GT. 0.)  GO TO 8330
      MMHRS(LIMEFS,TP) = ALIMFS(W)*TPSIZE
      TMS  (LIMEFS,TP) = PLIME*TPLANT(WVAR,LIMEFS)*365.*TPSIZE
      GO TO 8400
8330  MMHRS(LIMEFS,TP) = (ALIMFS(W)-ALIMFS(WO))*TPSIZE
      TMS  (LIMEFS,TP) = (PLIME*TPLANT(WVAR,LIMEFS)
     1                   -WOPLIM*TPLANT(PVAR,LIMEFS))*365.*TPSIZE
C
C        FERRIC CHLORIDE FEEDING AND STORAGE
8400  CONTINUE
      IF (EQUIP(FECLFS) .EQ. OFF)  GO TO 8500
      W = PFECL/3.95
      WO = WOPFC/3.95
      CMHRS(FECLFS,TP) = 0.
      IF (TPLANT(PPARM,FECLFS) .GT. 0.)  GO TO 8430
      MMHRS(FECLFS,TP) = 600.*TPSIZE
      IF (W .GT. 100.)  MMHRS(FECLFS,TP) = AFECFS(W)*TPSIZE
      TMS  (FECLFS,TP) = PFECL*TPLANT(WVAR,FECLFS)*365.*TPSIZE
      GO TO 8500
8430  MMHRS(FECLFS,TP) = (AFECFS(W)-AFECFS(WO))*TPSIZE
      TMS  (FECLFS,TP) = (PFECL*TPLANT(WVAR,FECLFS)
     1                   -WOPFC*TPLANT(PVAR,FECLFS))*365.*TPSIZE
C
C        POLYMER FEEDING AND STORAGE
8500  CONTINUE
      IF (EQUIP(POLYFS) .EQ. OFF)  GO TO 8600
      W = PPOLY/.020825
      WO = WOPPLY/.020825
      CMHRS(POLYFS,TP) = 0.
      IF (TPLANT(PPARM,POLYFS) .GT. 0.)  GO TO 8530
      MMHRS(POLYFS,TP) = 600.*TPSIZE
      IF (W .GT. 100.)  MMHRS(POLYFS,TP) = APLYFS(W)*TPSIZE
      TMS  (POLYFS,TP) = PPOLY*TPLANT(WVAR,POLYFS)*365.*TPSIZE
      GO TO 8600
8530  MMHRS(POLYFS,TP) = (APLYFS(W)-APLYFS(WO))*TPSIZE
      TMS  (POLYFS,TP) = (PPOLY*TPLANT(WVAR,POLYFS)
     1                   -WOPPLY*TPLANT(PVAR,POLYFS))*365.*TPSIZE
C
C        CARBON DIOXIDE FEEDING AND STORAGE
8600  CONTINUE
      IF (EQUIP(CO2FS) .EQ. OFF)  GO TO 8700
      IF (TPLANT(PPARM,CO2FS) .GT. 0.)  GO TO  8630
      OMHRS(CO2FS,TP) = CCO2FS(TPLANT(BPARM,CO2FS))*TPSIZE
      MMHRS(CO2FS,TP) = ACO2FS(TPLANT(BPARM,CO2FS))*TPSIZE
      TMS  (CO2FS,TP) = TCO2FS(QAVE*POPR)*TPSIZE
      GO TO 8700
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8630  OMHRS(CO2FS,TP) = 0.
      MMHRS(CO2FS,TP) = 0.
      TMS  (CO2FS,TP) = TCO2FS(QAVE*POPS)*TPSIZE
      IF (TP .LT. TPFADD(CO2FS))  GO TO 8700
      OMHRS(CO2FS,TP) = (OCO2FS(TPLANT(PPARM,CO2FS)
     1 +TPLANT(BPARM,CO2FS )) -OCO2FS(TPLANT(PPARM,CO2FS)))*TPSIZE
      MMHRS(CO2FS,TP) = (ACO2FS(TPLANT(PPARM,CO2FS)
     1 +TPLANT(BPARM,CO2FS )) -ACO2FS(TPLANT(PPARM,CO2FS)))*TPSIZE
C
C         SODIUM ALUMINATE FEEDING AND STORAGE
8700  CONTINUE
      IF (EQUIP(NAALFS) .EQ. OFF)  GO TO 8800
      W = PNAAL/5.4
      WO = WOPNAL/5.4
      OMHRS(NAALFS,TP) = 0.
      IF (TPLANT(PPARM,NAALFS) .GT. 0.)  GO TO 8730
      MMHRS(NAALFS,TP) = 600.*TPSIZE
      IF (W .GT. 100.)  MMHRS(NAALFS,TP) = ANALFS(W)*TPSIZE
      TMS  (NAALFS,TP) = PNAAL*TPLANT(WVAR,NAALFS)*365.*TPSIZE
      GO TO 8800
8730  MMHRS(NAALFS,TP) = (ANALFS(W)-ANALFS(WO))*TPSIZE
      TMS  (NAALFS,TP) = (PNAAL*TPLANT(WVAR,NAALFS)
     1                   -WOPNAL*TPLANT(PVAR,NAALFS))*365.*TPSIZE
C
C         PICKLING LIQUOR FEEDING AND STORAGE
8800  CONTINUE
      IF (EQUIP(PCKLFS) .EQ. OFF)  GO TO 8900
      W = PPCKL/2.6
      WO = WOPPCK/2.6
      OMHRS(PCKLFS,TP) = 0.
      IF (TPLANT(PPARM,PCKLFS) .GT. 0.)  GO TO 8830
      MMHRS(PCKLFS,TP) = 600.*TPSIZE
      IF (W .GT. 100.)  MMHRS(PCKLFS,TP) = APCKFS(W)*TPSIZE
      TMS  (PCKLFS,TP) = PPCKL*TPLANT(WVAR,PCKLFS)*365.*TPSIZE
      GO TO 8900
8830  MMHRS(PCKLFS,TP) = (APCKFS(W)-APCKFS(WO))*TPSIZE
      TMS  (PCKLFS,TP) = (PPCKL*TPLANT(WVAR,PCKLFS)
     1                   -WOPPCK*TPLANT(PVAR,PCKLFS))*365.*TPSIZE
C
C         SODIUM HYDROXIDE FEEDING AND STORAGE
C---      NO DATA FOR NAOHFS
8900  CONTINUE
      IF (EQUIP(NAOHFS) .EQ. OFF)  GO TO 9000
      OMHRS(NAOHFS,TP) = 0.
      MMHRS(NAOHFS,TP) = 0.
      TMS  (NAOHFS,TP) = 0.
C
C         RECALINATION
9000  CONTINUE
      IF (EQUIP(RECALC) .EQ. OFF)  GO TO 9100
      W = TPLANT(WPARM,RECALC)
      WO = TPLANT(WOPARM,RECALC)
      IF (TPLANT(PPARM,RECALC) .GT. 0.)  GO TO 9030
      OMHRS(RECALC,TP) = ORCALC(W)*TPSIZE
      MMHRS(RECALC,TP) = ARCALC(W)*TPSIZE
      TMS  (RECALC,TP) = TRCALC(W)*TPSIZE
      GO TO 9100
 9030 OMHRS(RECALC,TP) = (ORCALC(W)-ORCALC(WO))*TPSIZE
      MMHRS(RECALC,TP) = (ARCALC(W)-ARCALC(WO))*TPSIZE
      TMS  (RECALC,TP) = (TRCALC(W)-TRCALC(WO))*TPSIZE
C
C        FLOCCULATION BEFORE TERTIARY
 9100 CONTINUE
      IF (EQUIP(FLOCCT) .EQ. OFF)  GO TO 9200
      IF (TPLANT(PPARM,FLOCCT) .GT. 0.)  GO TO 9130
      OMHRS(FLOCCT,TP) = OFLCCT(TPLANT(BPARM,FLOCCT))*TPSIZE
      MMHRS(FLOCCT,TP) = AFLCCT(TPLANT(BPARM,FLOCCT))*TPSIZE
      TMS  (FLOCCT,TP) = TFLCCT(QAVE*POPR)*TPSIZE
      GO TO 9200
 9130 OMHRS(FLOCCT,TP) = 0.
      MMHRS(FLOCCT,TP) = 0.
      TMS  (FLOCCT,TP) = 0.
      IF (TP .LT. TPFADD(FLOCCT))  GO TO 9200
      OMHRS(FLOCCT,TP) = (OFLCCT(TPLANT(PPARM,FLOCCT)
     1 +TPLANT(BPARM,FLOCCT)) -OFLCCT(TPLANT(PPARM,FLOCCT)))*TPSIZE
      MMHRS(FLOCCT,TP) = (AFLCCT(TPLANT(PPARM,FLOCCT)
     1 +TPLANT(BPARM,FLOCCT)) -AFLCCT(TPLANT(PPARM,FLOCCT)))*TPSIZE
 9200 CONTINUE
C
C        CONVERT JAN 71 $ FOR MATERIAL & SUPPLY COSTS TO PRESENT LOCAL $
      DO 9900 IPROC = 1,MAXP
      TMS(IPROC,TP) = TMS(IPROC,TP) * MATRLS/1.122
 9900 CONTINUE
C
C        END OF SUBROUTINE TRT2
      RETURN
      END
      SUBROUTINE TSCHME(ES)
C
C        PURPOSE:
C           TSCHME INITIALIZES ALL THE DOMAIN VARIABLES NECESSARY TO
C           SIZE WPARM(J) (THE INDEPENDENT SIZING PARAMETER WITH
C           PHOSPHORUS REMOVAL TREATMENT FOR EACH PROCESS(J)).  THIS IS
C           DONE FOR A PARTICULAR ELIGIBLE TREATMENT SCHEME(ES).
C
C        COMMON BLOCKS:
C           LIQUID - LIQUID INFLUENT INFORMATION
C           PRGCNT - PROGRAM CONTROL VARIABLES
C           SLCHAR - SLUDGE,LIQUID,CHEMICAL CHARACTERISTICS
C           SLUDGE - SLUDGE CHARACTERISTICS
C           TPLANT - CHARACTERISTICS OF TREATMENT PROCESSES
C
C        CALLED BY:
C           SIZE   - THE INDEPENDENT PARAMETER SIZING SUBROUTINE
C
C        AUTHOR:
C           DAVID A BARNES    13OCT72
C
       COMMON /LIQUID/ ALKIPS, BODIPS, MLSSAR, NH3IAR, PINPS, QAVE
      1               , QPEAK, SSINPS, TBODAR

       REAL MLSSAR, NH3IAR

       COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
      1 , YES, NO, ON, OFF
      2 , ISCHM
      3 , IDUMMY, DUMMY

       EQUIVALENCE (IANSWR,ANSWER)

       INTEGER FIXED, FLOTE, ALPHA
       INTEGER YES, ON, OFF

       COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
      1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
      2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
      3 , ALTFMF, FCTFMF, ALFBAS, FCFBAS, L1FBAS, L2FBAS, NONE
      4 , EQUIP(45)

       INTEGER ELGBTY, EQUIP, SCHEME
       INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
      1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTFMF, FCTFMF, ALFBAS
      2 , FCFBAS
       REAL MINEFP

       COMMON /SLCHAR/    ADDSSR, ALKIAR, FCVFD , LBNVPS, LBNVSS
      1 , LBNVTS, LBVPS , LBVSS , LBVTS , LIMEPD, LMVFD , PALUM
      2 , PCO2  , PFECL , PNAAL , PNAOH , PCLYD , PPCKL , QPSLGE
      3 , QSSLGE, CTOTAL, QTSLGE, SRCAT , SRLIME, TLBNVS, TLBPS
      4 , TLBSLG, TLBSS , TLBTS , TLBVS , WOLBSS, WOPALM, WOPCO2
      5 , WOPFC , WOPLIM, WOPNAL, WOPNOH, WOPPLY, WOPPCK, WRCAT
      6 , PLIME , PYFTD , PYVFD , PPOLY , SRALF , SRCATA, WRALF
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     7 , SRFEF , WRFEF , SRFEP , SRALP , WRALP , WRFEP , WRALA
     8 , WRFEA , AARATO, FERATC, SRCATS, WRCATS, WRALS , WRFES
     9 , CO2D  , SRTLIM, TSETUD, LIMETD, BCDIAF, WDTLBS

      REAL       LBNVPS, LBNVSS, LBNVTS, LBVPS , LBVSS , LBVTS
     1 , LIMEPD, LMVED , LIMETD

      COMMON /SLUDGE/ ASD   , FLOTUD, GRAVUD, HPDFT , HPDVF , PSETUD
     1                 , PSRMVE, VFPSLG, VSANPM, VSARM

      COMMON /TPLANT/ TPLANT(16,45)
     1 , RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHAER, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGCCN, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
     6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     8 , WVAR  , BPARM , BASE  , APVAR , PARMX , MINRV , MAXRV
     9 , MAXP

      INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
     1 , DIFAIR, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, RE2PMP
     2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
     3 , CENFUG, FBINC , WSPOND, SLGCCN, RECRB1, RECRB2, TERST1
     4 , TERST2, ALUMFS, FECLFS, POLYFS, CO2FS , PCKLFS, RECALC
     5 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     6 , WVAR  , BPARM , FLOCCT, BASE  , APVAR , PARMX

      INTEGER ES

C        ************************************************************
C        ****************                            ****************
C        ****************     START EXECUTION        ****************
C        ****************                            ****************
C        ************************************************************
C
 1000 CONTINUE
      DO 1500 IPROC = 1,MAXP
      TPLANT(WVAR,IPROC) = TPLANT(PVAR,IPROC)
 1500 CONTINUE
      LBNVPS = 0.
      LBNVSS = 0.
      LBNVTS = 0.
      TLBNVS = 0.
      LBVPS = 0.
      LBVSS = 0.
      LBVTS = 0.
      TLBVS = 0.
      TLBPS = 0.
      TLBSS = 0.
      TLBTS = 0.
      TLBSLG = 0.
      QPSLGE = 0.
      QSSLGE = 0.
      QTSLGE = 0.
      QTOTAL = 0.
      ADDSSR = 0.
      ALKIAR = ALKIPS
      FCVFD = 0.
      LIMEPD = 0.
      LMVFD = 0.
      PALUM = 0.
      PCO2 = 0.
      PFECL = 0.
      PNAAL = 0.
      PNAOH = 0.
      PCLYD = 0.
      PPCKL = 0.
      SRCAT = 0.
      SRLIME = 0.
      WRCAT = 0.
      PLIME = 0.
      PYFTD = 0.
      PYVFD = 0.
      PPOLY = 0.
      SRALF = 0.
      SRCATA = 0.
      SRFEF = 0.
      WRFEF = 0.
      SRFEP = 0.
      WRFEP = 0.
      SRALP = 0.
      WRALP = 0.
      WRALA = 0.
      WRFEA = 0.
      WRCATS = 0.
      SRCATS = 0.
      AARATO = 0.
      FFRATO = 0.
      CO2D = 0.
      LIMETD = 0.
      SRTLIM = 0.
      TSETUD = 1.
      WRFES = 0.
      WRALS = 0.
      WRALF = 0.
      IF (ES .EQ. ALPYPS)  GO TO 2100
      IF (ES .EQ. FCPYPS)  GO TO 2300
      IF (ES .EQ. FCLMPS)  GO TO 2500
      IF (ES .EQ. LIMEPS)  GO TO 2700
      IF (ES .EQ. ALPYFB)  GO TO 2900
      IF (ES .EQ. FCPYFB)  GO TO 3100
      IF (ES .EQ. FCLMFB)  GO TO 3300
      IF (ES .EQ. LIMEFB)  GO TO 3500
      IF (ES .EQ. ALUMAB)  GO TO 3700
      IF (ES .EQ. FECLAB)  GO TO 3900
      IF (ES .EQ. NAALAB)  GO TO 4100
      IF (ES .EQ. ALABMF)  GO TO 4300
      IF (ES .EQ. FCABMF)  GO TO 4500
      IF (ES .EQ. NAABMF)  GO TO 4700
      IF (ES .EQ. ALUMTF)  GO TO 4900
      IF (ES .EQ. FECLTF)  GO TO 5100
      IF (ES .EQ. ALTEMF)  GO TO 5300
      IF (ES .EQ. FCTEMF)  GO TO 5500
      IF (ES .EQ. ALFBAS)  GO TO 5700
      IF (ES .EQ. FCFBAS)  GO TO 5900
      IF (ES .EQ. L1FBAS)  GO TO 6100
      IF (ES .EQ. L2FBAS)  GO TO 6300
      IF (ES .EQ. NONE)    GO TO 6400
 2100 CONTINUE
C           ALUM + POLYMER TO PRIMARY SETTLER
C
      WRALP = 2.
      SRALP = 5.7
      WRCAT = WRALP
      SRCAT = SRALP
      PSETUD = .03
      AARATO = 11.
 2130 CONTINUE
      ADDSSR = 50.
      BODIAR = .5 * BODIPS
      POLYD = .5
      GRAVUD = .05
 2135 CONTINUE
      TPLANT(WVAR,GRVTKN) = 8.
      IF (EQUIP(TRKFTR) .EQ. OFF)  GO TO 2140
      GRAVUD = .06
      TPLANT(WVAR,GRVTKN) = 10.
      IF (EQUIP(AERBSN) .EQ. OFF)  GO TO 2140
      GRAVUD = .04
      TPLANT(WVAR,GRVTKN) = 8.
 2140 CONTINUE
      IF (EQUIP(AERBSN) .EQ. ON .AND. (EQUIP(ANADIG) .EQ. OFF
     1 .AND. EQUIP(AERDIG) .EQ. OFF))  GO TO 2151
      IF (EQUIP(TRKFTR) .EQ. ON .AND. (EQUIP(ANADIG) .EQ. OFF
     1 .AND. EQUIP(AERDIG) .EQ. OFF))  GO TO 2153
      IF (EQUIP(AERBSN) .EQ. ON .AND. (EQUIP(ANADIG) .EQ. ON
     1 .OR.  EQUIP(AERDIG) .EQ. ON ))  GO TO 2155
      IF (EQUIP(TRKFTR) .EQ. ON .AND. (EQUIP(ANADIG) .EQ. ON
     1 .OR.  EQUIP(AERDIG) .EQ. ON ))  GO TO 2157
 2151 FCVFD = 70.
      LMVFD = 100.
      TPLANT(WVAR,VACFTR) = 3.
      GO TO 2159
 2153 FCVFD = 40.
      LMVFD = 160.
      TPLANT(WVAR,VACFTR) = 5.
      GO TO 2159
 2155 FCVFD = 70.
      LMVFD = 180.
      TPLANT(WVAR,VACFTR) = 3.
      GO TO 2159
```

```
2157  FCVFD =60.
      LMVFD = 160.
      TPLANT(WVAR,VACFTR) = 4.
      GO TO 2159
2159  CONTINUE
      TPLANT(WVAR,CRYBED) = 2.6
      IF (EQUIP(TRKFTR) .EQ. ON)  TPLANT(WVAR,CRYBED) = 1.8
      RETURN
2300  CONTINUE
C           FERRIC CHLORIDE + POLYMER TO PRIMARY SETTLER
C
      WRFEP = 3.1
      SRFEP = 2.4
      WRCAT = WRFEP
      SRCAT = SRFEP
      PSETUD = .02
      FFRATO = 2.89
      GO TO 2130
2500  CONTINUE
C           FERROUS CHLORIDE + LIME TO PRIMARY SETTLER
C
      WRFEP = 3.1
      SRFEP = 2.4
      WRCAT = WRFEP
      SRCAT = SRFEP
      LIMEPD = 15.
      IF (ALKIPS .GT. 300.)  LIMEPD = 0.
      SRLIME = 4000.
      FFRATO = 2.27
      PSETUD = .08
      GO TO 2135
2700  CONTINUE
C           LIME TO PRIMARY SETTLER
C
      LIMEPD = 150.
      IF (ALKIPS .GT. 300.)  LIMEPD = 200.
      SRLIME = 4000.
      ADDSSR = 50.
      BODIAR = .5 * BODIPS
      PSETUD = .05
      GRAVUD = .09
      TPLANT(WVAR,GRVTKN) = 20.
      IF (EQUIP(TRKFTR) .EQ. OFF)  GO TO 2740
      GRAVUD = .08
      TPLANT(WVAR,GRVTKN) = 15.
      IF (EQUIP(AERBSN) .EQ. OFF)  GO TO 2740
      GRAVUD = .07
      TPLANT(WVAR,GRVTKN) = 10.
2740  CONTINUE
      FCVFD = 0.
      EQUIP(FECLFS) = OFF
      LMVFD = 0.
      TPLANT(WVAR,VACFTR) = 6.
      IF (EQUIP(TRKFTR) .EQ. ON)  TPLANT(WVAR,VACFTR) = 7.
      RETURN
```

```
 2900  CONTINUE
 C          ALUM + POLYMER TO FLOCCULATION BASIN BEFORE PRIMARY
 C
       GO TO 2100
 3100  CONTINUE
 C          FERRIC CHLORIDE + POLYMER TO FLOCCULATION BASIN
 C
       GO TO 2300
 3300  CONTINUE
 C          FERROUS CHLORIDE + LIME TO FLOCCULATION BASIN
 C
       GO TO 2500
 3500  CONTINUE
 C          LIME TO THE FLOCCULATION BASIN BEFORE PRIMARY
 C
       GO TO 2700
 3700  CONTINUE
 C          ALUM TO THE AERATION BASIN
 C
       WRALA = 2.
       SRCATA = 4.
       AARATO = 11.
 3730  CONTINUE
       ASC = .015
       GRAVUD= .07
       TPLANT(WVAR,GRVTKN) = 12.
       FCVFD = 70.
       LMVFD = 100.
       TPLANT(WVAR,VACFTR) = 6.
       IF (EQUIP(ANADIG) .EQ. OFF .AND. EQUIP(AERDIG) .EQ. OFF) GOTO 3740
       FCVFD = 70.
       LMVFD = 180.
       TPLANT(WVAR,VACFTR) = 5.
 3740  CONTINUE
       TPLANT(WVAR,CRYBED) = 2.4
       RETURN
 3900  CONTINUE
 C          FERRIC CHLORIDE TO AERATION BASIN
 C
       WRFEA = 3.5
       SRCATA = 2.4
       FFRATO = 2.89
       GO TO 3730
 4100  CONTINUE
 C          SODIUM ALUMINATE TO AERATION BASIN
 C
       WRALA = 2.
       SRCATA = 4.
       AARATO = 4.22
       GO TO 3730
 4300  CONTINUE
 C          ALUM TO AERATION BASIN + MULTI-MEDIA FILTRATION
 C
       WRALA = 2.
       SRCATA = 8.
```

```
      AARATO = 11.
      GO TO 3730
4500  CONTINUE
C            FERRIC CHLORIDE TO AERATION BASIN + MULTI-MEDIA FILTER
C
      WRFEA = 3.5
      SRCATA = 4.8
      FFRATO = 2.89
      GO TO 3730
4700  CONTINUE
C            SODIUM ALUMINATE TO AERATION BASIN + MULTI-MEDIA FILTER
C
      WRALA = 2.
      SRCATA = 8.
      AARATO = 4.22
      GO TO 3730
4900  CONTINUE
C        ALUM AFTER TRICKLING FILTER
C
      WRALF = 1.5
      SRALF = 3.6
      AARATO = 11.
4930  CONTINUE
      GRAVUD = .08
      TPLANT(WVAR,GRVTKN) = 15.
      FCVFD = 40.
      LMVFD = 160.
      TPLANT(WVAR,VACFTR) = 7.
      IF (EQUIP(ANADIG) .EQ. OFF .AND. EQUIP(AERDIG) .EQ. OFF) GOTO 4940
      FCVFD = 60.
      LMVFD = 160.
      TPLANT(WVAR,VACFTR) = 6.
4940  CONTINUE
      TPLANT(WVAR,DRYBED) = 2.4
      RETURN
5100  CONTINUE
C         FERRIC CHLORIDE AFTER TRICKLING FILTER
C
      WRFEF = 4.
      SRFEF = 2.4
      FFRATO = 2.89
      GO TO 4930
5300  CONTINUE
C         ALUM AFTER TRICKLING FILTER + MULTI-MEDIA FILTRATION
C
      WRALF = 1.5
      SRALF = 8.
      AARATO = 11.
      GO TO 4930
5500  CONTINUE
C         FERRIC CHLORIDE AFTER TRICKLING FILTER + MULTI-MEDIA FILTER
C
      WRFEF = 4.
      SRFEF = 4.8
      FFRATO = 2.89
      GO TO 4930
5700  CONTINUE
C             ALUM TO FLOCCULATION BASIN AFTER CONVENTIONAL SECONDARY
C
      WRALS = 2.
      SRALS = 3.6
      WRCATS = WRALS
      SRCATS = SRALS
      AASATO = 11.
      TSETUD = .015
5730  CONTINUE
      GRAVUD = .06
      TPLANT(WVAR,GRVTKN) = 10.
      IF (EQUIP(TRKFTR) .EQ. OFF)  GO TO 5740
      GRAVUD = .07
      TPLANT(WVAR,GRVTKN) = 12.
5740  CONTINUE
      IF (EQUIP(AERBSN) .EQ. ON .AND. (EQUIP(ANADIG) .EQ. OFF
     1 .AND. EQUIP(AERDIG) .EQ. OFF))  GO TO 5751
      IF (EQUIP(TRKFTR) .EQ. ON .AND. (EQUIP(ANADIG) .EQ. OFF
     1 .AND. EQUIP(AERDIG) .EQ. OFF))  GO TO 5753
      IF (EQUIP(AERBSN) .EQ. ON .AND. (EQUIP(ANADIG) .EQ. ON
     1 .OR.  EQUIP(AERDIG) .EQ. ON ))  GO TO 5755
      IF (EQUIP(TRKFTR) .EQ. ON .AND. (EQUIP(ANADIG) .EQ. ON
     1 .OR.  EQUIP(AERDIG) .EQ. ON ))  GO TO 5757
5751  FCVFD = 70.
      LMVFD = 100.
      TPLANT(WVAR,VACFTR) = 5.
      GO TO 5759
5753  FCVFD = 40.
      LMVFD = 160.
      TPLANT(WVAR,VACFTR) = 6.
      GO TO 5759
5755  FCVFD = 70.
      LMVFD = 180.
      TPLANT(WVAR,VACFTR) = 6.
      GO TO 5759
5757  FCVFD =60.
      LMVFD = 160.
      TPLANT(WVAR,VACFTR) = 5.
      GO TO 5759
5759  CONTINUE
      TPLANT(WVAR,DRYBED) = 2.4
      RETURN
5900  CONTINUE
C             FERRIC CHLORIDE TO FLOCC. AFTER CONVEN. SECONDARY
C
      WRFES = 4.
      SRFES = 2.4
      WRCATS = WRFES
      SRCATS = SRFES
      FERATO = 2.69
      GO TO 5730
6100  CONTINUE
C             LIME(1-STAGE) TO FLOCC. AFTER CONVEN. SECONDARY
```

```
C
      LIMETD = 150.
      IF (ALKIPS .GT. 300.)  LIMETD = 200.
      SRTLIM = 3000.
      CO2D = 1400.*1.2
      TSETUD = .04
 6130 CONTINUE
      GRAVUD = .10
      TPLANT(NVAR,GRVTKN) = 20.
      RETURN
 6300 CONTINUE
C           LIME(2-STAGE) TO FLOCC. AFTER CONVEN. SECONDARY
C
      LIMETD = 300.
      IF (ALKIPS .GT. 150)  LIMETD = 400.
      SRTLIM = 7000.
      CO2D = 3000.*1.2
      TSETUD = .03
      GO TO 6130
 6400 CONTINUE
C
C        NO CHEMICALS ADDED FOR PHOSPHORUS REMOVAL
C
      BODIAR = .7 * BODIPS
      GRAVUD = .08
      TPLANT(PVAR,GRVTKN) = 20.
      IF (EQUIP(TRKFTR) .EQ. OFF)  GO TO 6420
      GRAVUD = .07
      TPLANT(PVAR,GRVTKN) = 12.
 6420 CONTINUE
      IF (EQUIP(AERBSN) .EQ. OFF)  GO TO 6430
      GRAVUD = .06
      TPLANT(PVAR,GRVTKN) = 10.
 6430 CONTINUE
      IF (EQUIP(AERBSN) .EQ. ON .AND. (EQUIP(ANADIG) .EQ. OFF
     1 .AND. EQUIP(AERDIG) .EQ. OFF))  GO TO 6451
      IF (EQUIP(TRKFTR) .EQ. ON .AND. (EQUIP(ANADIG) .EQ. OFF
     1 .AND. EQUIP(AERDIG) .EQ. OFF))  GO TO 6453
      IF (EQUIP(AERBSN) .EQ. ON .AND. (EQUIP(ANADIG) .EQ. ON
     1 .OR. EQUIP(AERDIG) .EQ. ON))  GO TO 6455
      IF (EQUIP(TRKFTR) .EQ. ON .AND. (EQUIP(ANADIG) .EQ. ON
     1 .OR. EQUIP(AERDIG) .EQ. ON))  GO TO 6457
 6451 FCVFD = 70.
      LMVFD = 100.
      TPLANT(PVAR,VACFTR) = 4.5
      GO TO 6459
 6453 FCVFD = 40.
      LMVFD = 160.
      TPLANT(PVAR,VACFTR) = 7.
      GO TO 6459
 6455 FCVFD = 70.
      LMVFD = 180.
      TPLANT(PVAR,VACFTR) = 4.
      GO TO 6459
 6457 FCVFD = 60.
```

```
      LMVFD = 160.
      TPLANT(PVAR,VACFTR) = 4.5
      GO TO 6459
6459  CONTINUE
      TPLANT(PVAR,CRYBED) = 2.3
      IF (EQUIP(TRKFTR) .EQ. ON)  TPLANT(PVAR,CRYBED) = 1.6
      RETURN
C         END OF SUBROUTINE TSCHME
      END
```

SECTION IX

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SECTION X

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SECTION XI

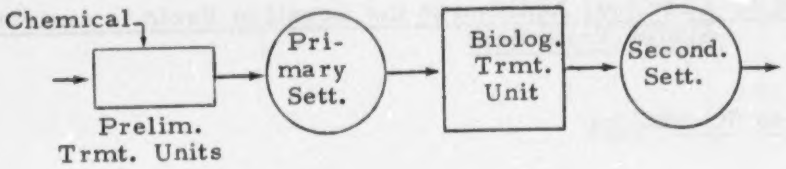
APPENDICES

APPENDIX A

Liquid-Phase Treatment System Options For Phosphorus Removal

System Option 1: Addition to the Primary Clarifier

A. Process Schematic*


Chemical
Prelim. Trmt. Units
Pri-mary Sett.
Biolog. Trmt. Unit
Second. Sett.

*only major treatment units are shown. Buildings, pumps, etc. are omitted for simplicity. Also, processes incidental to P-removal, e.g., chlorine contact basins, are not included.

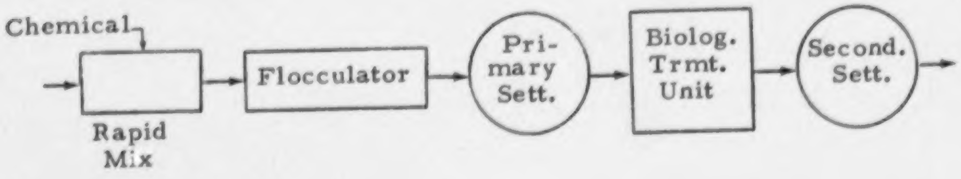
B. Attainable Effluent P: 2 mg/l (either option)

C. Alternative Chemical Additives

1. Lime
2. Alum + Polyelectrolyte
3. Pickle Liquor or $FeCl_2$ & lime
4. $FeCl_3$ + Polyelectrolyte

System Option 2: Addition to a Flocculation Basin Prior to Primary Clarifier

A. Process Schematic


Chemical
Rapid Mix
Flocculator
Pri-mary Sett.
Biolog. Trmt. Unit
Second. Sett.

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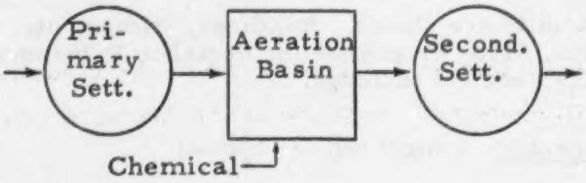
B. Attainable Effluent P: 2 mg/l

C. Alternative Chemical Additives

1. Lime
2. Alum + Polyelectrolyte
3. Pickle Liquor or $FeCl_2$ & lime
4. $FeCl_3$ + Polyelectrolyte

System Option 3: Chemical Addition to the Aeration Basin in Activated Sludge Treatment

A. Process Schematics


Pri-
mary
Sett.
Aeration
Basin
Second.
Sett.
Chemical

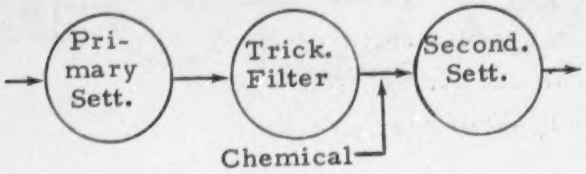
B. Achievable Effluent P: 2 mg/l

C. Alternative Chemical Additives

1. Alum
2. $FeCl_3$
3. Pickle Liquor or $FeCl_2$ (not one of the modeled schemes)
4. Sodium Aluminate

System Option 4: Chemical Addition to Trickling Filter Effluent

A. **Process Schematics**


Pri-
mary
Sett.
Trick.
Filter
Second.
Sett.
Chemical

B. **Achievable Effluent P:** 2 mg/l

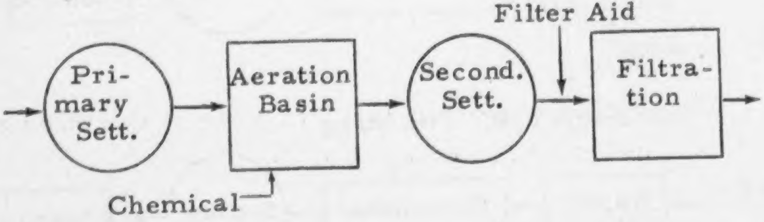
C. **Alternative Chemical Additives**

1. Alum
2. $FeCl_3$
3. Pickle Liquor or $FeCl_2$ (not one of the modeled schemes)
4. Sodium Aluminate (not one of the modeled schemes)

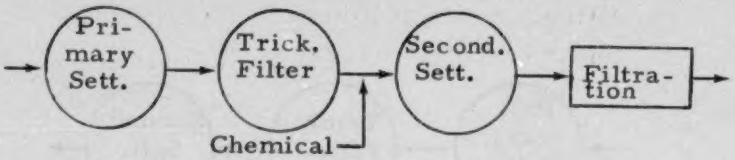
System Option 5: Option 3 or 4 Plus Multi-Media Filtration

A. **Process Schematics**

1. Sub-option 5-A.


Filter Aid
Pri-
mary
Sett.
Aeration
Basin
Second.
Sett.
Filtra-
tion
Chemical

2. Sub-option 5-B.


Primary Sett.
Trick. Filter
Second. Sett.
Filtration
Chemical

B. **Achievable Effluent P:** 0.5 mg/l

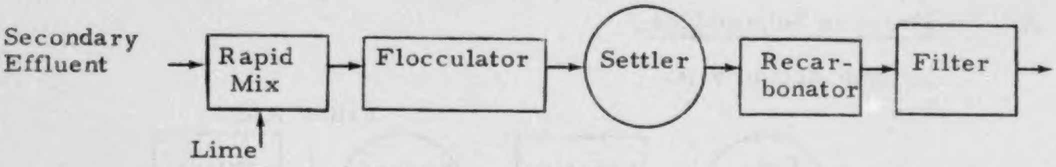
C. **Alternative Chemical Additives**

1. Alum
2. $FeCl_3$
3. Pickle Liquor or $FeCl_2$ (not one of the modeled schemes)
4. Sodium Aluminate

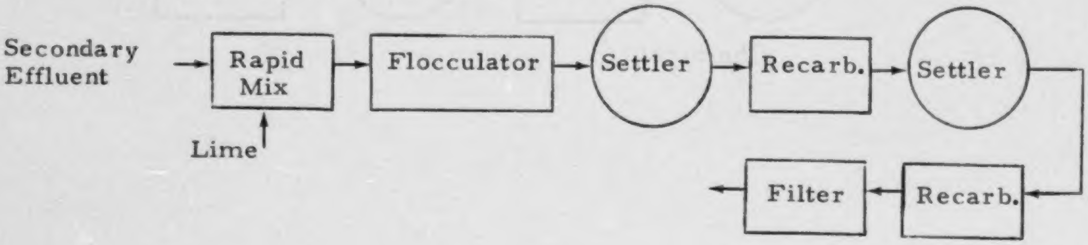
System Option 6: Lime Addition to Secondary Effluent

A. **Process Schematics**

1. Sub-option 6-A. Single Stage


Secondary Effluent
Rapid Mix
Lime
Flocculator
Settler
Recarbonator
Filter

2. Sub-option 6-B. Two Stage

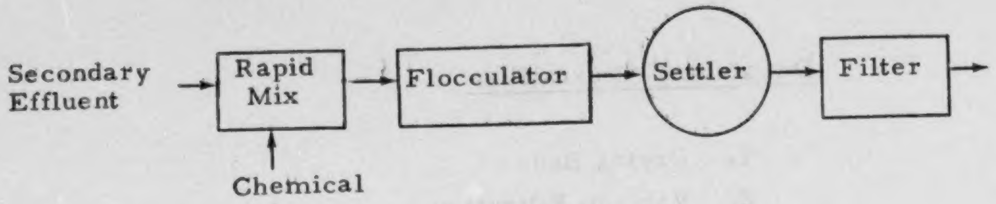

Secondary Effluent
Rapid Mix
Lime
Flocculator
Settler
Recarb.
Settler
Recarb.
Filter

B. Achievable Effluent P

Option 6-A Single Stage	0.5 mg/l
Option 6-B Two Stage	0.1 mg/l

System Option 7: Alum Addition to Secondary Effluent

A. Process Schematic


Secondary Effluent
Rapid Mix
Chemical
Flocculator
Settler
Filter

B. Achievable Effluent P: 0.3 mg/l

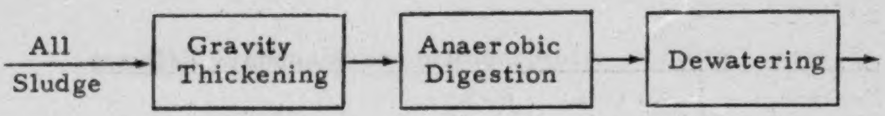
C. Alternate Chemical Additives

1. Alum
2. $FeCl_3$

APPENDIX B

Sludge Handling System Options

Option 1


All Sludge
Gravity Thickening
Anaerobic Digestion
Dewatering

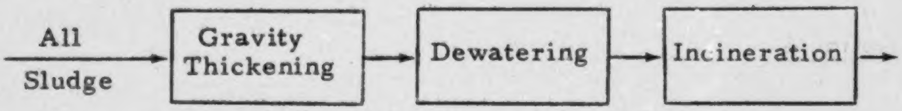
Dewatering Alternatives

1. Drying Beds
2. Vacuum Filtration
3. Centrifugation

Application

Existing plant contains anaerobic digester, no incinerator

Option 2


All Sludge
Gravity Thickening
Dewatering
Incineration

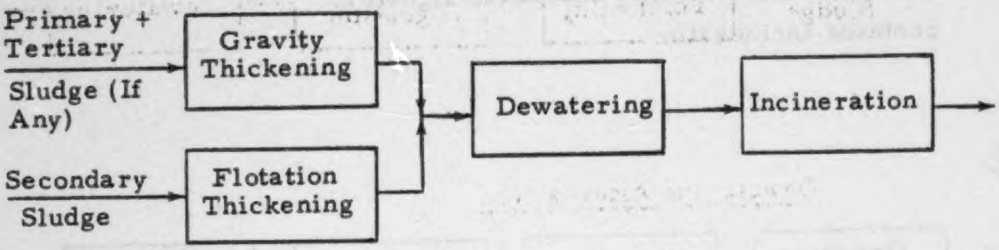
Dewatering Alternatives

1. Vacuum Filtration
2. Centrifugation

Application

Existing plant treats primary and secondary sludge in combination, has incinerator

Option 3


Primary + Tertiary Sludge (If Any)
Secondary Sludge
Gravity Thickening
Flotation Thickening
Dewatering
Incineration

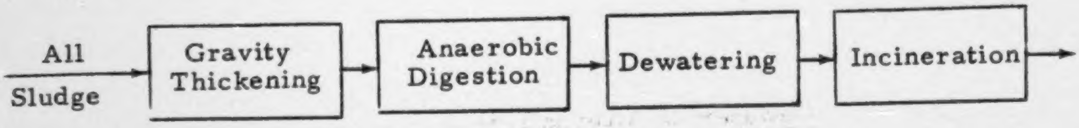
Dewatering Alternatives

1. Vacuum Filtration
2. Centrifugation

Application

Existing plant has flotation thickener

Option 4


All Sludge
Gravity Thickening
Anaerobic Digestion
Dewatering
Incineration

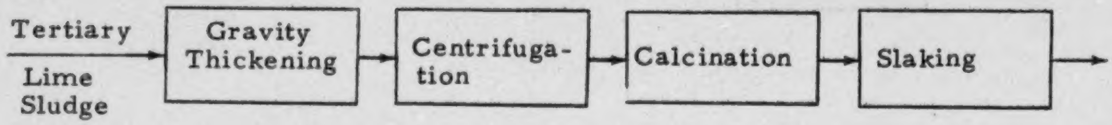
Dewatering Alternatives

1. Vacuum Filtration
2. Centrifugation

Application

Existing plant contains anaerobic digester, contains incinerator

Option 5


Tertiary
Lime Sludge
Gravity Thickening
Centrifugation
Calcination
Slaking

Application

Phosphorus removal scheme selected is lime addition to secondary effluent

Note

Thickening and dewatering processes used in this option are independent of any similar processes used in primary and secondary sludge handling "upstream" in the plant.

APPENDIX C

Design Parameters

Type of Sludge	Sludge % Solids		Design Solids Loading lb/sq ft/day
	Unthickened	Thickened	
A. No Chemical Added			
Primary	4	8	20
Primary & Trickling Filter	4	7	12
Primary & Activated	3	6	10
B. Lime Addition Before Primary			
Primary	5	9	20
Primary & Trickling Filter	5	8	15
Primary & Activated	4	7	10
C. Fe or Al Addition Before Primary			
Primary	2	5	8
Primary & Trickling Filter	3	6	10
Primary & Activated	1.5	4	8
D. Fe or Al Addn. to Aerator			
Primary & Activated	4	7	12
E. Chemical Addn. to Trickling Filter Effluent			
Primary & Trickling Filter	5	8	15
F. Fe or Al Addn. to Secondary Effluent			
Primary & Activated & Tertiary	3	6	10
Primary & Trickling Filter & Tertiary	4	7	12
G. Lime Addn. to Sec. Effluent			
Tertiary Lime Sludge	3	10	20

DESIGN PARAMETERS FOR VACUUM FILTRATION

Type of Sludge	Liquid & Solids Processing Options From Which Sludge Is Derived	Design Yield (lbs/sq ft/hr)	Chemical Dose (lb/Ton Solids)	
			$FeCl_3$ as $FeCl_3$	Lime as CaO
A. No Chemical Added				
Primary & Activated	--	4.5	70	100
Primary & Trickling Filter	--	7	40	160
Digested Primary & Activated	--	4	70	180
Digested Primary & Trickling Filter	--	4.5	60	160
B. Lime Addition Before Primary	L. O. I			
Primary & Activated	S. O. II, III	6		
Primary & Trickling Filter	S. O. II, III	7		
C. Fe or Al Addn Before Primary	L. O. I			
Primary & Activated	S. O. II, III	3	70	100
Primary & Trickling Filter	S. O. II, III	5	40	160
Digested Primary & Activated	S. O. I, IV	3	70	180
Digested Primary & Trickling Filter	S. O. I, IV	4	60	160
D. Fe or Al Addn to Aerator	L. O. II			
Primary & Activated	S. O. II, III	6	70	100
Digested Primary & Activated	S. O. I, IV	5	70	180
E. Chemical Addn to Trickling Filter	L. O. III			
Primary & Trickling Filter	S. O. II, III	7	40	160
Digested Primary & Trickling Filter	S. O. I, IV	6	60	160
F. Fe or Al Add to Secondary Effl.	L. O. V			
Primary & Activated Tertiary	S. O. II, III	5	70	100
Primary & Trickling Filt. & Tertiary	S. O. II, III	6	40	160
Digested Primary & Activated & Tert.	S. O. I, IV	6	70	180
Digested Primary & Trick. Filt & Tert.	S. O. I, IV	5	60	160

DESIGN PARAMETERS FOR SLUDGE DRYING BEDS

Type of Sludge	Bed Area Requirement (sq ft/capita)		
	Open Beds		Covered Beds
	North	South	
A. No Chemical Added			
Digested Primary & Activated	2.3	1.8	1.4
Digested Primary & Trickling Filter	1.6	1.3	1.1
B. Fe or Al Add'n Before Primary			
Primary & Activated Digested	2.6	2.0	1.6
Primary & Trickling Filter Digested	1.8	1.5	1.3
C. Fe or Al Add'n to Aerator to Trick Filt Effl, or to Secondary Effl			
Primary & Secondary & Tertiary (if any) Digested	2.4	2.1	1.4

DESIGN PARAMETERS FOR ANAEROBIC DIGESTION, FLOTATION THICKENING AND MULTIPLE HEARTH INCINERATION*

Conventional Anaerobic Digestion

Organic Loading Factor = 40 lb VSS/day/1000 cu ft

Hydraulic Loading Factor = 30 days detention

High-Rate Anaerobic Digestion

Organic Loading Factor = 150 lb VSS/day/1000 cu ft

Hydraulic Loading Factor = 15 days detention

Multiple Hearth Incinerator

Solids Loading Factor = 2 lb/hr/sq ft hearth area

Air Flotation Thickening

Solids Loading Factor = 2 lb/hr/sq ft

Chemical Dose = 10 lbs Polymer/ton

*Design parameters for these processes are assumed to be independent of the liquid-phase processing and sludge handling scheme selected.

*U.S. GOVERNMENT PRINTING OFFICE:1973 546-311/102 1-3

1 *Accession Number*

W

2 *Subject Field & Group*

06B

SELECTED WATER RESOURCES ABSTRACTS
INPUT TRANSACTION FORM

5 *Organization*

JBF Scientific Corporation

6 *Title*

A Computer Model For Evaluating Local Phosphorus Removal Strategies

10 *Author(s)*

Donald S. Yeaple
David A. Barnes
Francis A. DiGiano

16 *Project Designation*

Contract No. 68-01-0758

21 *Note*

22 *Citation*

23 *Descriptors (Starred First)*

*Phosphorus, *Water Pollution Treatment, *Evaluation, *Costs, Local Governments, Eutrophication

25 *Identifiers (Starred First)*

*Phosphorus Removal Strategies, Chemical Treatment, Detergents

27 *Abstract*

A computer model for evaluating a number of strategies for removing phosphorus in wastewater has been developed. The influence on total treatment cost of several non-treatment strategies such as the elimination of phosphates in detergents can be evaluated in terms of the treatment cost at local waste treatment plants.

A review of phosphorus removal technology was conducted in order to determine what methods should be included as available techniques in a treatment strategy. Chemical precipitation techniques were selected as being both available and most effective at the present time and in the immediate future.

The model reports to the user the total cost of a selected strategy for removing phosphorus. Over 21 treatment schemes with several sludge handling schemes can be selected and evaluated depending on local conditions. The computer guides the user through a series of questions and answers to develop a local profile and prediction of future conditions.

Abstractor Donald S. Yeaple

Institution JBF Scientific Corporation

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